This lesson is being recorded

King's InterHigh

LEADING ONLINE SCHOOL

Explore 1: Laundry Machine

Electricity – Potential Dividers

Objective

Understand how the **potential** along a uniform current-carrying wire **varies** with the distance along it.

Understand the **principles** of a potential divider circuit and understand how to calculate potential differences and resistances in such a circuit.

Be able to analyse potential divider circuits where one resistance is variable including thermistors and light dependent resistors (LDRs).

Starter – Multiple Answer

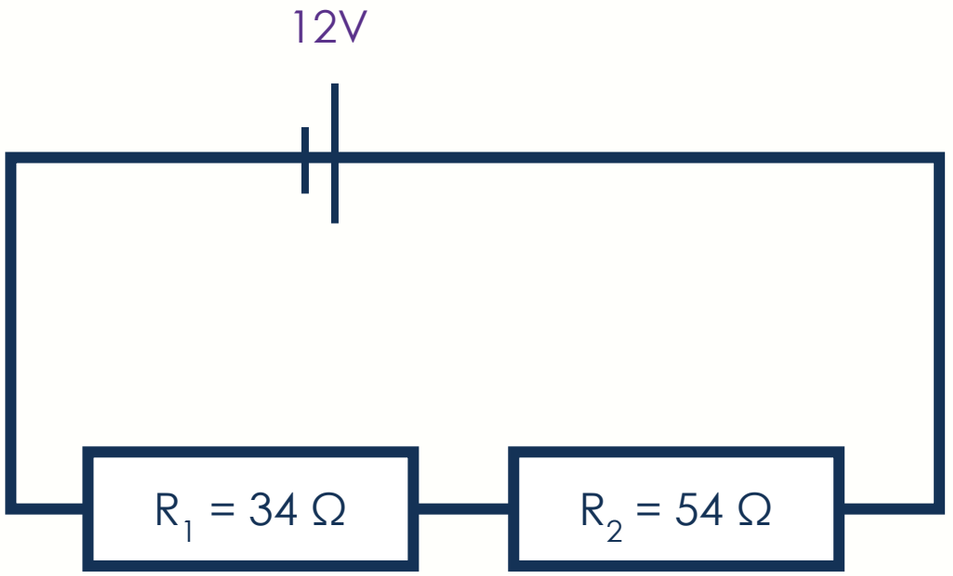
What will increasing the resistance of R_1 change?

A. The voltage across R_1

B. The voltage across R_2

C. The current through R_1

D. The current through R_2



- A, B, C and D
- One's voltage will increase, two's will decrease.
- The current will decrease by the same amount for both.

Activity: Washing line mission

Your mission is to design an automatic washing line.

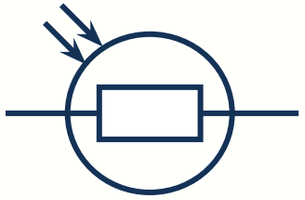
It must sense:

- Heat
- Rain (lack of)
- Sunshine

To put the laundry out it must be:

- Dry
- Sunny and/or warm

Thermistor



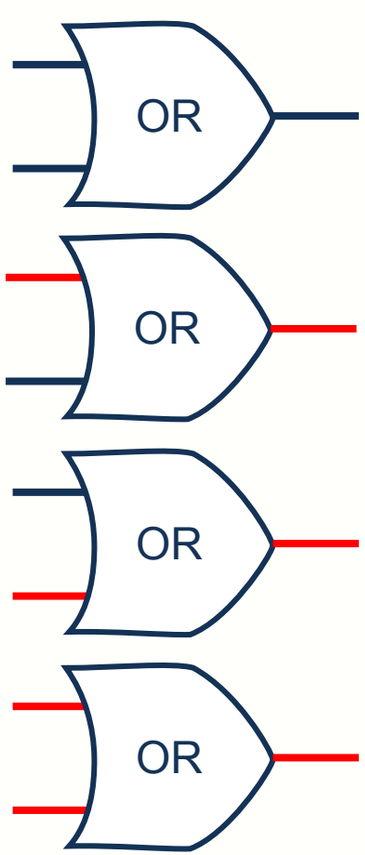
LDR

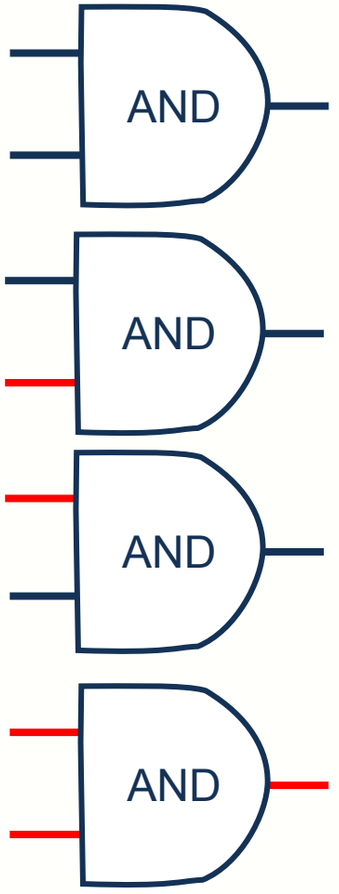
Moisture detector

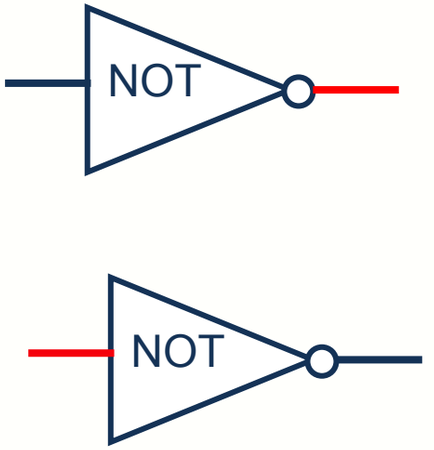
Logic Gates

You have these logic gates to help you.

Red means there is a current.

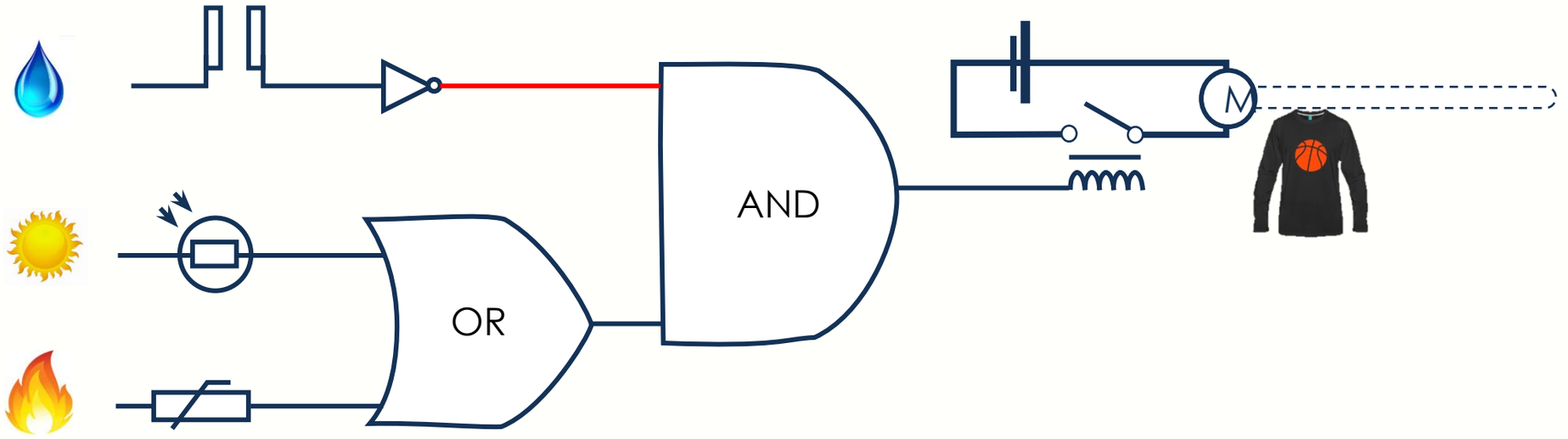






Blank slide to draw on in Breakouts

Solution



Rain	Warm	Sunny	Out?
0	0	0	0
0	0	1	1
0	1	0	1
0	1	1	1
1	0	0	0
1	0	1	0
1	1	0	0
1	1	1	0

Plenary

Fill in the blanks

- A potential divider is a part of a circuit with two comp[1]
- Typically, one component is var[2]tor.
- The other is often a thermistor or a LDR[3]
- Together they control an output volt[4]

Objective

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Be able to analyse potential divider circuits where one resistance is variable including thermistors and light dependent resistors (LDRs).

Explore 2: Exam Practice I

Electricity – Potential Dividers

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Starter

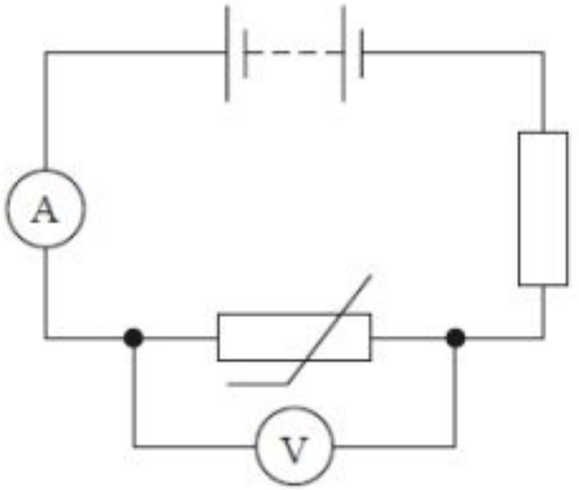
Write any points or questions you have relating to potential dividers.

Points

Questions

Q1

A student investigated the effect of temperature on the resistance of a thermistor, using the circuit shown.



A negative temperature coefficient thermistor was used in this circuit.

With reference to the charge carriers in the thermistor, explain what happens to the p.d. across the thermistor as the temperature increases.

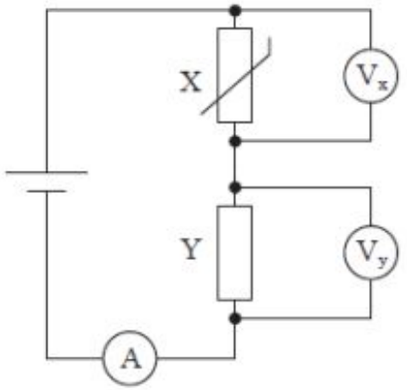
(3)

Q1

Question Number	Acceptable answers	Additional guidance	Mark
	• As temperature increases number of (free) charge carriers (in thermistor) increases so its resistance decreases **Or** As temperature increases number of charge carriers in conduction band increases so (thermistor) resistance decreases (1) • Thermistor resistance as a proportion of total resistance decreases (1) **Or** (1) Current increases so p.d. across resistor increases • P.D. (across thermistor) decreases	Accept electrons for charge carriers	3

Q2

The diagram shows a potential divider circuit that contains a negative temperature coefficient thermistor.



The temperature of the room containing the circuit increases.

Select the row of the table that correctly shows the changes in readings on the meters.

	V_x	V_y	A
☒ **A**	decrease	increase	decrease
☒ **B**	decrease	increase	increase
☒ **C**	increase	decrease	decrease
☒ **D**	increase	decrease	increase

(Total for question = 1 mark)

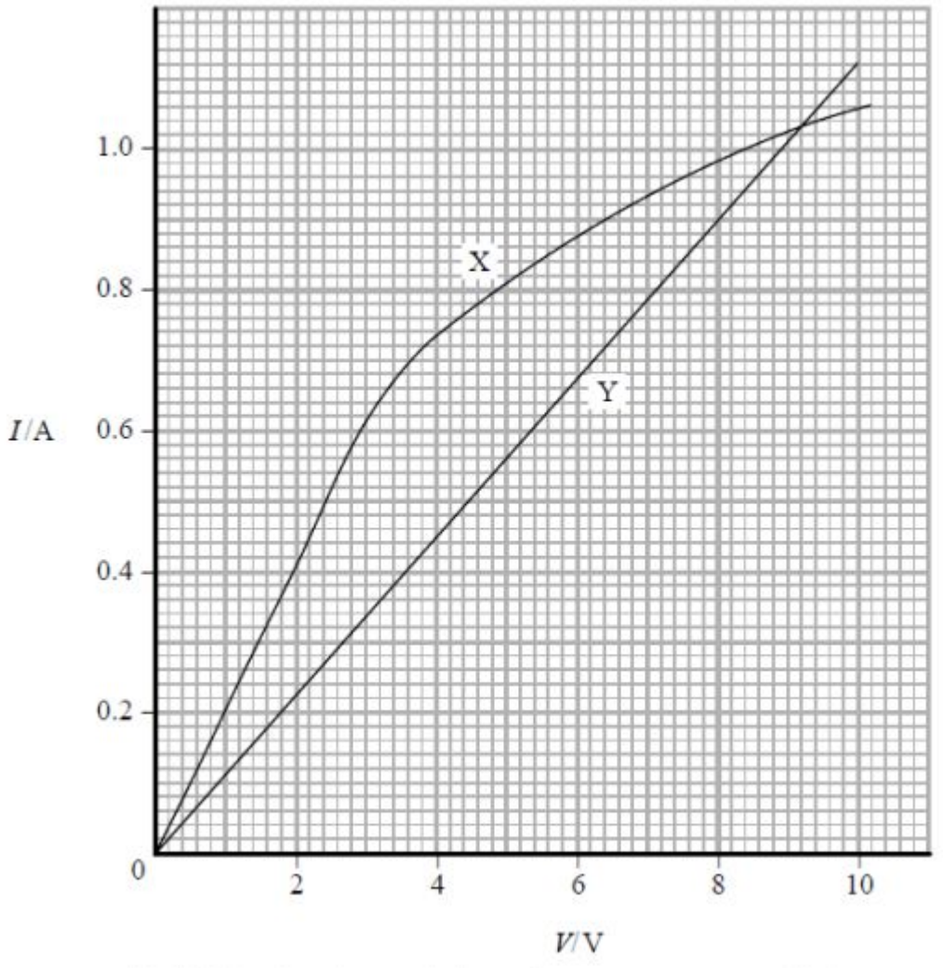
Q2

Question Number	Answer	Mark
	B	1

Q3

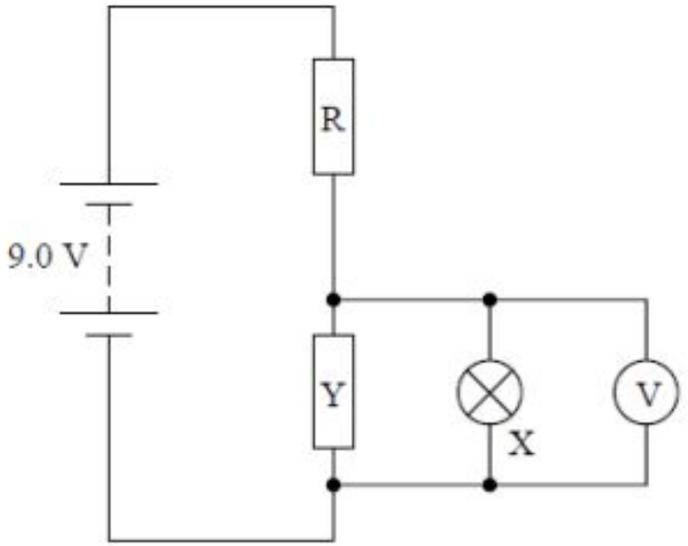
The graph shows the variation of current *I* with potential difference *V* for two electrical components X and Y.

X is a filament bulb and Y is a fixed resistor.



Q3

A potential divider circuit consisting of components X and Y is connected to a 9.0 V supply in series with a fixed resistor R as shown. The supply has a negligible internal resistance.



The reading on the voltmeter is 3.0 V.

(i) Determine the current in the fixed resistor R.

(2)

Q3

(ii) Component X is removed from the circuit.

Explain, without further calculation, how this would change the voltmeter reading.

(3)

Q3

Question Number	Acceptable Answer	Additional Guidance	Mark
(i)	• Reads current values at 3V for both components **(1)** • Current through fixed resistor R = 0.94 A **(1)**	Current values are 0.33 (A) and 0.61 (A) Allow tolerance of ± 0.01 A Allow tolerance of ± 0.02 A	2
(ii)	An explanation that makes reference to: • resistance of Y will be greater than resistance of parallel combination **(1)** • Y will have a greater share of the p.d **(1)** **OR** R will have a lower share of the p.d. **(1)** • so the reading on the voltmeter will increase. **(1)** **OR** • the current through R decreases **(1)** • as V = IR, the p.d. across R decreases**(1)** • so the p.d. across Y and the voltmeter reading will increase **(1)**	To score the final marking point candidates must score both MP1 and MP2	3

Plenary

Play taboo with words and phrases related to this topic….

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Explore 3: Practical

Electricity – Potential Dividers

Objective

Build a virtual potential divider.

Starter

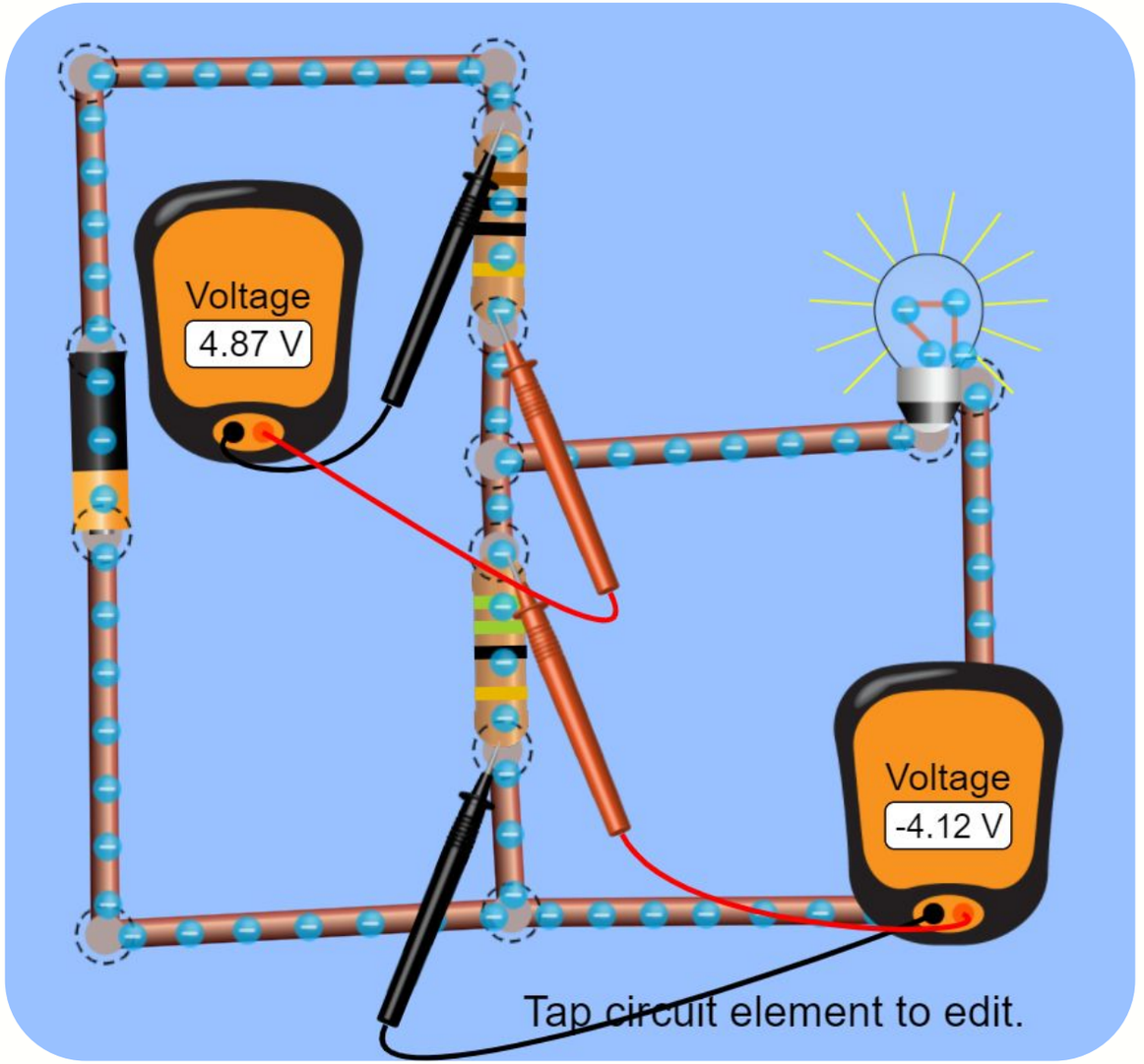
Why are potential dividers useful?

What two things do they allow you to do?

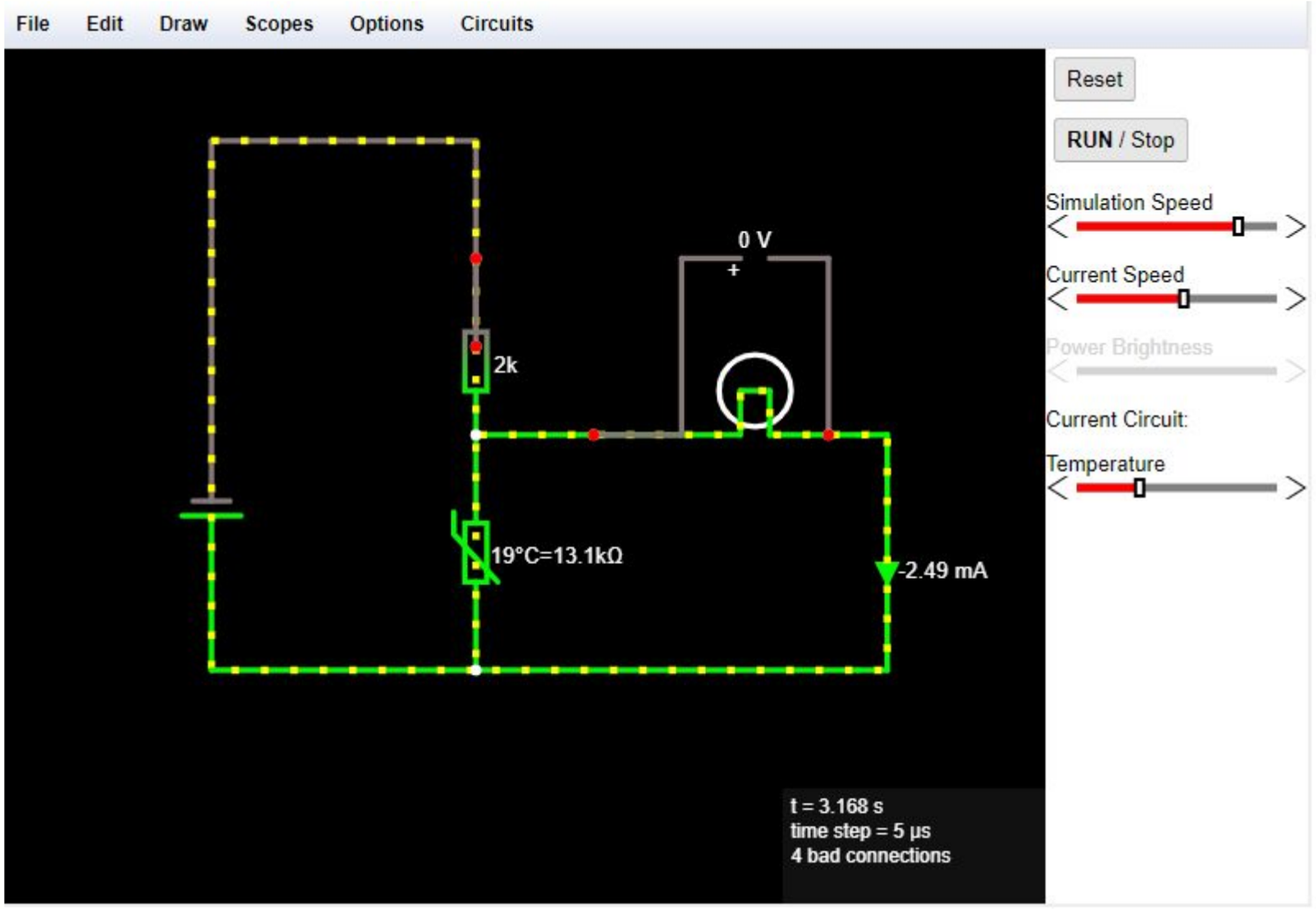
- They allow a device to work automatically and respond to an outside stimulus, like temperature.
- You can set the conditions for the response action: example - at what temperature the heating comes on

Phet

- Build this circuit.
- Adjust the resistors and note the effect on voltage.



Alternative / Extension



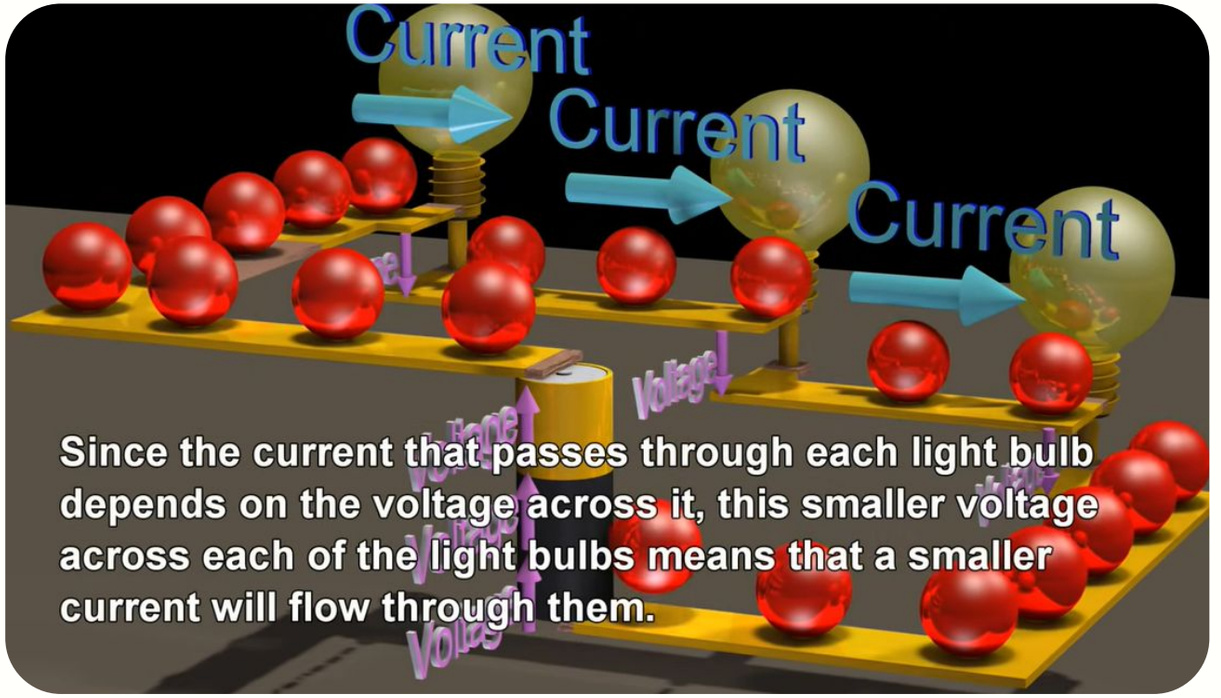
- This sim is a bit more fiddly but does allow you do more.

Plenary

Watch the 6.45 min onwards.

How is its metaphor useful for Potential Dividers?

- The more one step drops the marble the less height there is for the other component.



Electric Circuits: Basics of the voltage and current laws
9.47 min

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Be able to analyse potential divider circuits where one resistance is variable including thermistors and light dependent resistors (LDRs).

Explore 4: Exam Practice II

Electricity – Potential Dividers

Objective

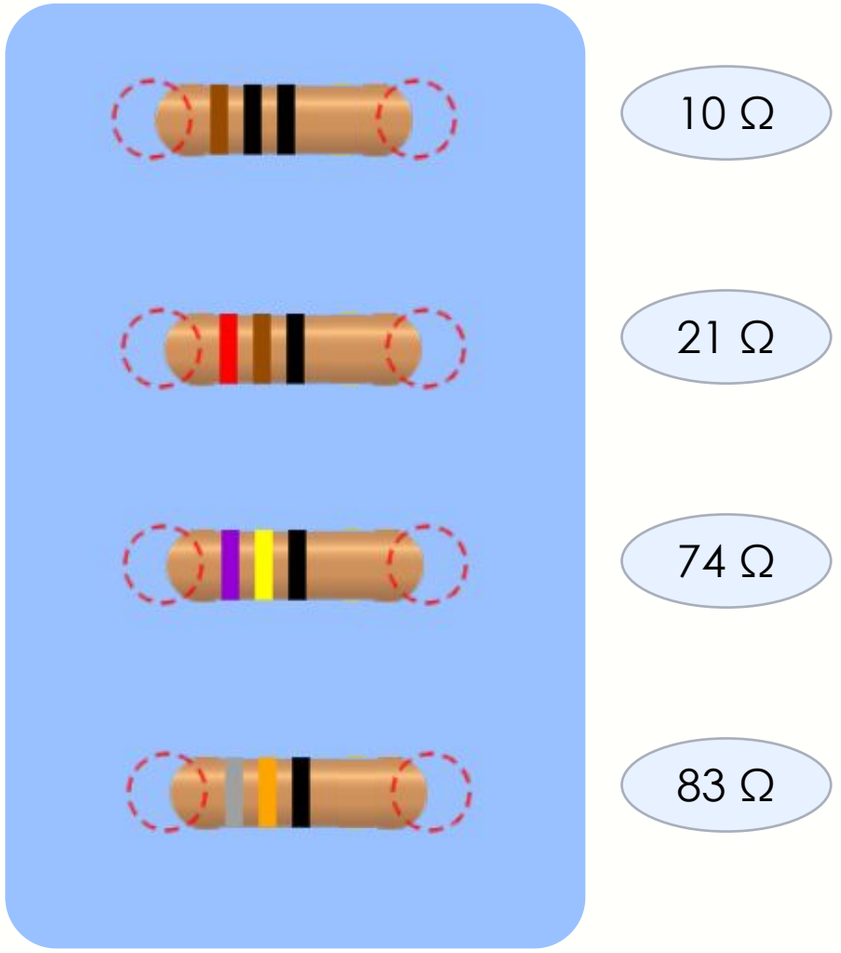
Understand how the **potential** along a uniform current-carrying wire **varies** with the distance along it.

Understand the **principles** of a potential divider circuit and understand how to calculate potential differences and resistances in such a circuit.

Be able to analyse potential divider circuits where one resistance is variable including thermistors and light dependent resistors (LDRs).

Starter

Can you work out the resistances?



A

B

C

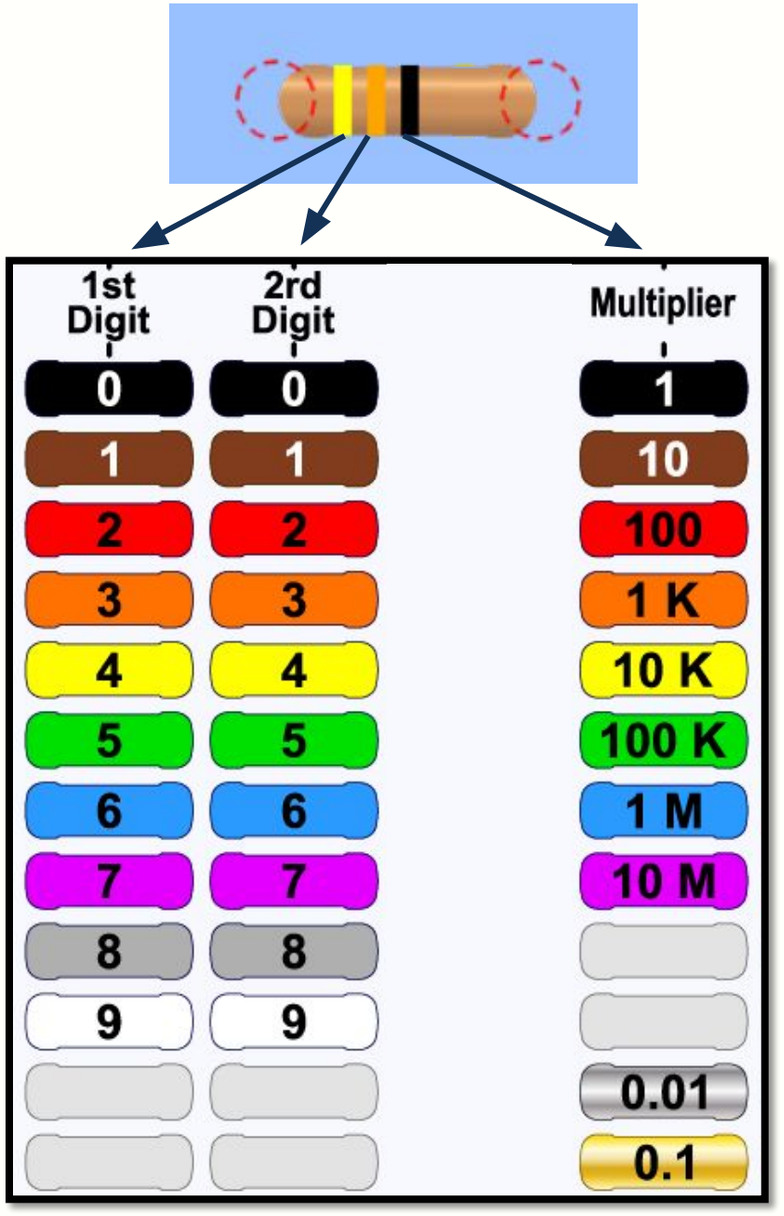
D

10 Ω

21 Ω

74 Ω

83 Ω

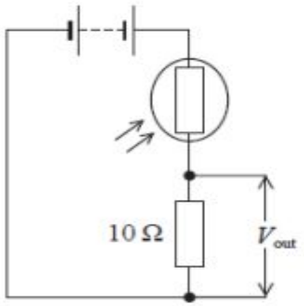


Q1

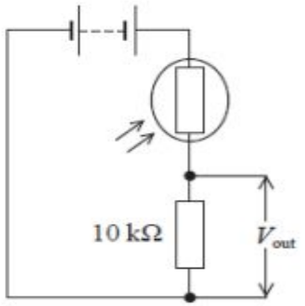
When a light dependent resistor is illuminated, its resistance falls from 1000 kΩ to 0.1kΩ.

The light dependent resistor is connected in series with a fixed resistor.

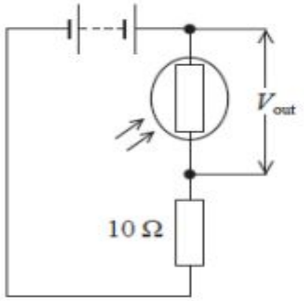
Which of the circuits shown would produce the greatest output potential difference V_{out} when illuminated?



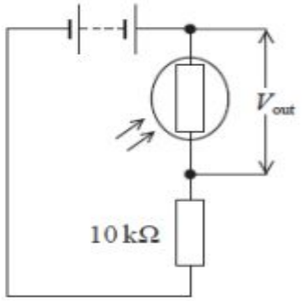
☒ A



☒ B

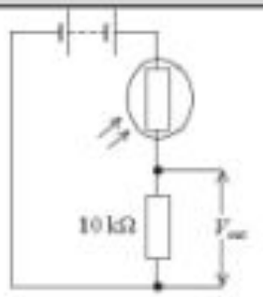


☒ C



☒ D

Q1

Question Number	Answers	Additional Guidance	Mark
	B		**(1)**

Q2

A series circuit consists of two resistors with resistances R_1 and R_2 and a battery of potential difference V.

Which of the following gives the potential difference across the resistor with resistance R_2?

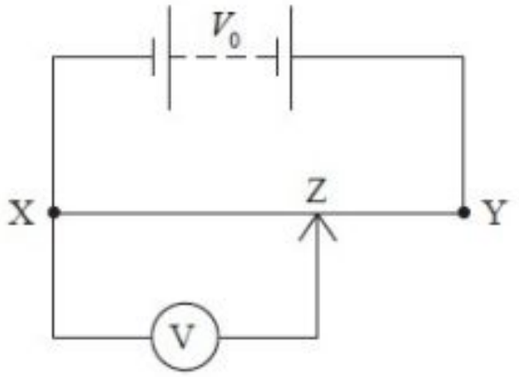
- ☐ **A** $\frac{R_1}{R_2} V$
- ☐ **B** $\frac{R_2}{R_1} V$
- ☐ **C** $\frac{R_1}{R_1 + R_2} V$
- ☐ **D** $\frac{R_2}{R_1 + R_2} V$

Q2

Question Number	Answer	Mark
	D $\frac{R_2}{R_1+R_2}V$	**1**
	Incorrect Answers: A – this looks similar to the correct formula but has an incorrect resistance as the numerator and does not have the total resistance as the denominator B – this looks similar to the correct formula with the correct resistance as the numerator but does not have the total resistance as the denominator C – This would give the PD across resistor R_1 and not R_2	

Q3

Q6. The diagram shows a uniform wire XY across which a potential difference V_0 is applied.



Which of the following correctly shows the output potential difference across XZ?

☐ **A** $V = \frac{XY}{XZ}V_0$

☐ **B** $V = \frac{XZ}{XY}V_0$

☐ **C** $V = \frac{XZ}{ZY}V_0$

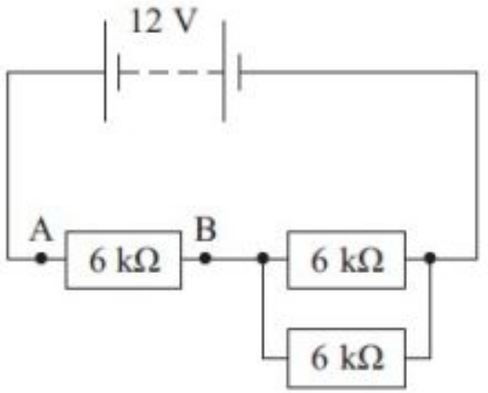
☐ **D** $V = \frac{ZY}{XY}V_0$

Q3

Question Number	Answer	Mark
	B	1

Q4

A combination of resistors is connected to a 12 V supply of negligible internal resistance.



The potential difference between points A and B is

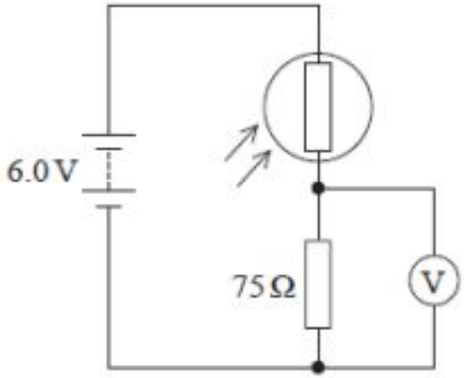
- ☒ **A** 4 V
- ☒ **B** 6 V
- ☒ **C** 8 V
- ☒ **D** 12 V

Q4

Question Number	Answer	Mark
	C	1

Q5

A student set up a circuit containing a light dependent resistor (LDR) in series with a fixed resistor as shown.



When the lamp was at a distance of 10 cm from the LDR, the reading on the voltmeter was 2.4V.

Calculate the resistance of the LDR at this distance.

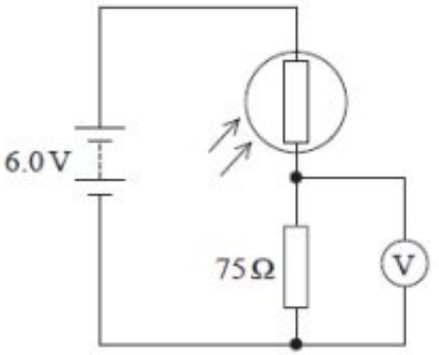
(3)

Q5

Question Number	Acceptable Answer	Additional Guidance	Mark
	• potential difference across the LDR = 3.6 V (1) **Or** $\frac{R}{(R+75\ \Omega)}$ seen **Or** $\frac{75\ \Omega}{(R+75\ \Omega)}$ seen • Use of $V = IR$ (1) **Or** resistance ratio × 6.0 V = corresponding p.d. • $R = 110\ \Omega$ (1)	MP2 use of $V = IR$ with 2.4 V or 3.6 V only Example of calculation $I = 2.4\ V/75\ \Omega = 0.032\ A$ Voltage across LDR = 6.0 V – 2.4 V = 3.6 V $R = \frac{3.6\ V}{0.032 A}$ $R = 112.5\ \Omega$ **Or** use of ratios $\frac{75\ \Omega}{(R+75\ \Omega)} \times 6.0\ V = 2.4\ V$ $R = 112.5\ \Omega$	3

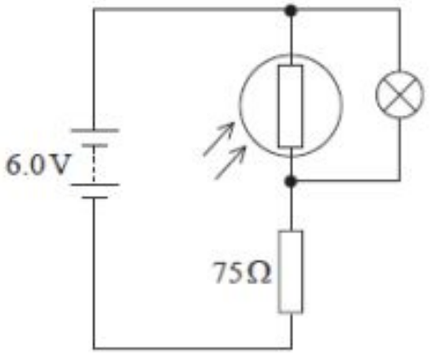
Q6

A student set up a circuit containing a light dependent resistor (LDR) in series with a fixed resistor as shown.



The student wants to modify the circuit so that a light bulb lights up when the room goes dark.

She modifies the circuit as shown below. When working normally the resistance of the light bulb is 3Ω and the p.d. across it is 3V.



Explain, without further calculation, whether this circuit would work as intended.

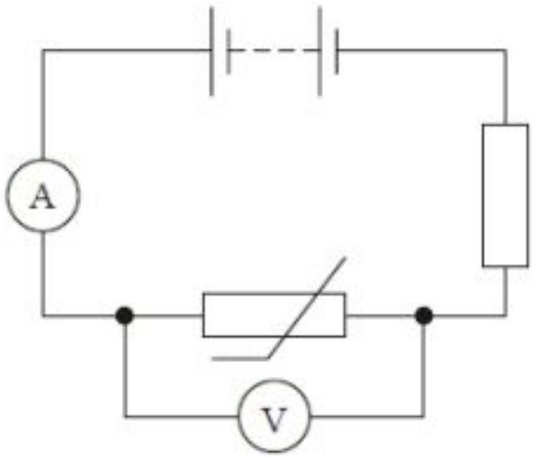
(3)

Q6

Question Number	Acceptable Answer	Additional Guidance	Mark
	An explanation that makes reference to the following: • Combined resistance of (light) bulb and LDR is about 3 Ω (in the dark) **Or** the combined resistance is less than the resistance of bulb/LDR (1) • The combined resistance is always much less than the (75 Ω) fixed resistance (1) • The p.d. across the bulb will be much less than 3 V and so the bulb will **not** come on (in the dark). (1)	MP3: accept the idea that the p.d. across the bulb is never high enough to make the bulb come on in the dark	3

Q7

A student investigated the effect of temperature on the resistance of a thermistor, using the circuit shown.



The voltmeter was an analogue voltmeter of resistance 45 kΩ.

The thermistor was placed in a beaker of ice and the current and potential difference (p.d.) at a temperature of 0 °C were recorded.

The manufacturer of the thermistor states that at 0 °C the thermistor has a resistance of 9.7 kΩ.

(i) Comment on the suitability of using the analogue voltmeter for measuring the p.d. across the thermistor. Your answer should include a suitable calculation.

(3)

Q7

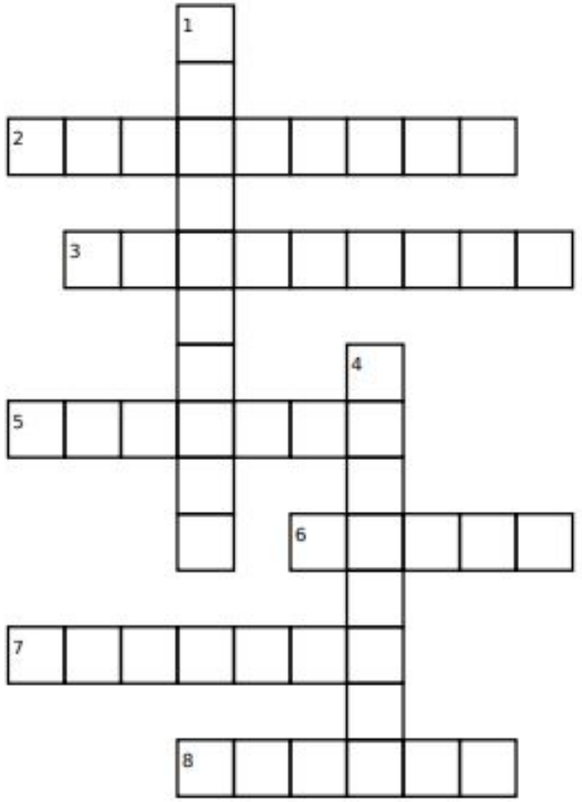
(ii) Explain why connecting the voltmeter across both the ammeter and the thermistor would improve the experiment. The ammeter had negligible resistance.

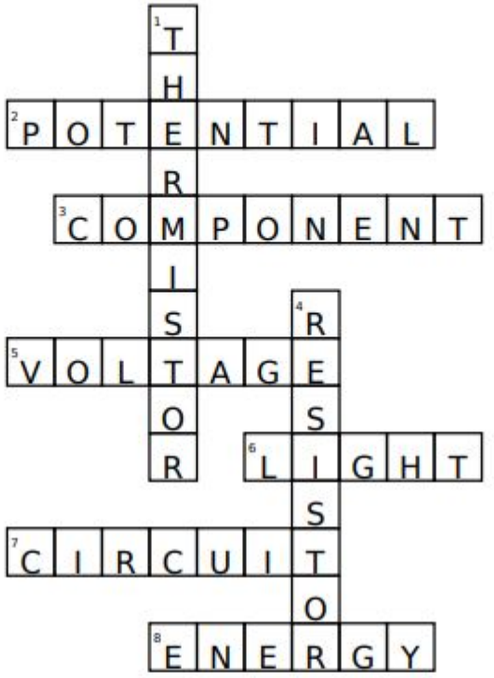
(2)

Q7

Question Number	Acceptable answers		Additional guidance	Mark
(i)	• Use of $\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2}$ to determine the total resistance of the parallel branch	(1)	Example of calculation $\frac{1}{R_{TP}} = \frac{1}{9.7\ \text{k}\Omega} + \frac{1}{45\ \text{k}\Omega}$	
	• $R_{TP} = 8.0\ \text{k}\Omega$	(1)	$R_{TP} = 7.98\ \text{k}\Omega$	
	• Comparison of measured to actual resistance	(1)	MP3: 7.98 kΩ is significantly less than 9.7 kΩ, so unsuitable	
	OR	(1)		
	• Same p.d. across thermistor and voltmeter	(1)		
	• Calculation of ratio of currents	(1)	MP3 dependent on MP2	3
	• States that current through voltmeter is significant			
(ii)	• Current flows through the voltmeter	(1)		
	• But in the new arrangement, the ammeter would read only the current passing through the thermistor **Or** current through ammeter equals current through thermistor	(1)		2

Plenary





Down:

1. responds to heat
4. slows current

Across:

2. _ _ _ _ _ _ _ _ _ divider
3. bulb is an example
5. unit is joules per Coulomb
6. _ _ _ _ _ dependent resistor
7. components connects to a cell
8. makes current flow

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Lesson complete!

See you next lesson