PRESTON MANOR

# Physics Exam Pack

## Potential dividers

Name: Date:

| Question / Paper | Mark |
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3 **(a)** Kirchhoff's laws can be used to analyse any electrical circuit. State each of Kirchhoff's laws and the physical quantity associated with each law that is conserved in the circuit.

**(i)** Kirchhoff's first law

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..... **[2]**

**(ii)** Kirchhoff's second law

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**(b)** The circuit in Fig. 3.1 consists of a battery of e.m.f. 45 V and negligible internal resistance and three resistors.

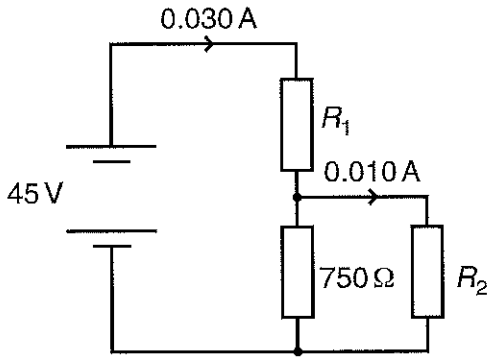



**Fig. 3.1**

The resistors have resistances $R_1$, $R_2$ and 750 Ω. The current in the resistor of resistance $R_1$ is 0.030 A. The current in the resistor of resistance $R_2$ is 0.010 A.

Calculate

**(i)** the current $I$ in the 750 Ω resistor

$I$ = ..... A **[1]**

**(ii)** the p.d. $V$ across the 750 Ω resistor

$V$ = .....V **[1]**

**(iii)** the resistances $R_1$ and $R_2$.

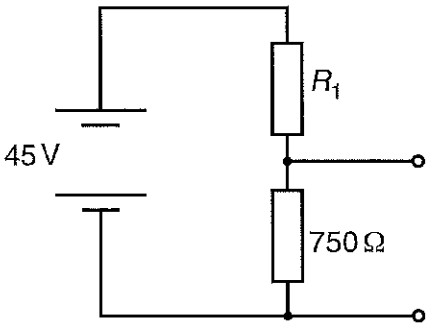
$R_1$ = ..... Ω

$R_2$ = ..... Ω
**[2]**

**Question 3 is continued on page 8**

**(c)** The resistor of resistance $R_2$ is replaced in Fig. 3.1 by a light dependent resistor (LDR).

**(i)** Draw the circuit symbol for an LDR on Fig. 3.2 to complete this new circuit.




**[1]**

**Fig. 3.2**

**(ii)** The resistance of the LDR falls from about 1.5 kΩ to about 400 Ω as the light intensity increases. State and explain, without calculation, how the potential difference across the 750 Ω resistor varies as the intensity of the light incident on the LDR increases.

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**(iii)** It is suggested that the LDR in the circuit of Fig. 3.2 is used to monitor changes in the light intensity.

**1** Draw a suitable electrical meter in the LDR branch of the circuit on Fig. 3.2 to measure these changes.

**2** State the electrical meter that you have chosen and suggest a sensible maximum scale reading.

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**[3]**

**[Total: 15]**

| Question | | | Answer | Marks | Guidance |
|---|---|---|---|---|---|
| 3 | (a) | (i) | sum of/total current into a junction equals the sum of/total current out<br>conservation of charge | B1<br>B1 | total vector sum of currents is zero<br>**allow** 'point in a circuit' for 'junction' |
| | | (ii) | (sum of) e.m.f.s = sum /total of p.d.s/sum of voltages in/around a (closed) loop (in a circuit)<br>energy is conserved | B1<br>B1 | **allow** 'in a (closed) circuit' in place of 'loop' |
| | (b) | (i) | current in 750 Ω = 0.020 A | A1 | **allow** 20 mA **or** 0.02 A |
| | | (ii) | V across 750 Ω = 0.02 x 750 = 15 V | A1 | **ecf b(i)** |
| | | (iii) | $R_1$ = (45 – 15)/0.03 = 1000 Ω<br>$R_2$ = 15/0.01 = 1500 Ω | A1<br>A1 | **ecf b(ii)** |
| | (c) | (i) | correct symbol connected in circuit | B1 | 2 arrows pointing towards the resistor at about $45^0$ with or without a circle; arrows outside circle if drawn |
| A<br>A<br>A | | (ii) | total R falls<br>so I in circuit/in $R_1$ increases<br>so V across $R_1$ increases and V across 750 Ω falls | B1<br>M1<br>A1 | **accept** sum of R's in parallel falls<br>$R_1$ is fixed so V across $R_1$ increases<br>so V across R's in parallel falls (so V across 750 Ω falls)<br>**or** correct potential divider argument |
| | | (iii) | in series with LDR: ammeter (A); 50 mA<br>in parallel with LDR: voltmeter (V); 20 V | M1<br>A1<br>B1 | **allow** voltmeter in parallel with $R_1$ (30 – 50 V)<br>**allow** multimeter connected as A (series) or V (parallel) and a correct unit for range given<br>**allow** 20 to 100 mA; or 15 to 50 V |
| | | | **Total** | **15** | |

3 Fig. 3.1 shows a circuit containing a battery of e.m.f. 12V, two resistors, a light-dependent resistor (LDR), an ammeter and a switch **S**. The battery has negligible internal resistance.

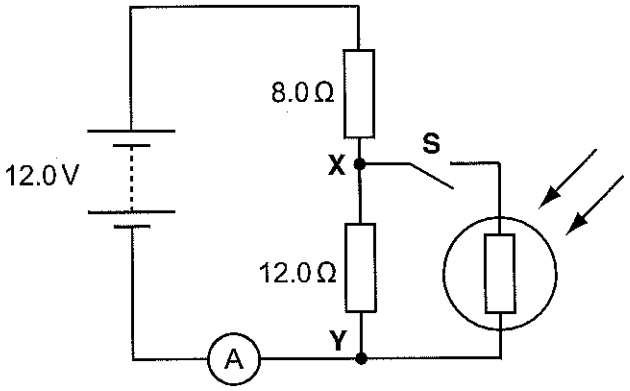


**Fig. 3.1**

**(a)** When the switch **S** is open, show that the potential difference between the points **X** and **Y** is 7.2V.

**[2]**

**(b)** The switch **S** is now closed. Describe and explain the change to each of the following when the intensity of light falling on the LDR is increased:

**(i)** the ammeter reading

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..... **[2]**

**(ii)** the potential difference across **XY**.

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..... **[2]**

**[Total: 6]**

| Question | | | Expected Answers | Marks | Additional Guidance |
|---|---|---|---|---|---|
| 3 | | | | | |
| | a | | resistors in series add to 20 Ω and current is 0.60 A<br>so p.d. across XY is 0.60 x 12 (= 7.2 V) | B1<br>B1 | **accept** potential divider stated **or** formula gives (12 /20) x 12 V (= 7.2 )V |
| | b | i | the resistance of the LDR decreases<br>(so total resistance in circuit decreases) and current increases | M1<br>A1 | |
| | | ii | resistance of LDR and 12 Ω (in parallel)/across **XY** decreases<br>so has smaller share of supply p.d. (and p.d. across XY falls) | B1<br>B1 | **alternative I** increases so p.d. across 8.0 Ω increases; so p.d. across **XY** falls |
| | | | **Total question 3** | **6** | |

| Question | | | Expected Answers | Marks | Additional Guidance |
|---|---|---|---|---|---|
| 4 | | | | | |
| | a | i | no current/no light/does not conduct until V is greater than 1.5 V<br>brightness/intensity of LED increases with current/voltage above 1.5 V<br>above 1.8 V current rises almost linearly with increase in p.d./AW<br>the LED does not obey Ohm's law<br>as I is not proportional to V/AW<br>below 1.5 V, LED acts as an infinite R/ very high R/acts as open switch<br>above 1.5 V, LED resistance decreases (with increasing current/voltage) | B1<br>B1<br>B1<br>M1<br>A1<br>B1<br>B1 | **allow** 1.4 to 1.6 V (QWC mark)<br>(alternative QWC mark)<br><br><br><br>**max 5 marks** which must include at least one of the first 2 marking points |
| | | ii 1<br>2 | infinite resistance<br>I = 23.0 ± 1.0 (mA)<br>R = $1.9 \times 10^3/(23 \pm 1) = 83 \pm 4$ Ω | B1<br>C1<br>A1 | <br><br>**apply** POT error for 0.083 Ω |
| | b | | LED symbol with correct orientation<br>resistor (need not be labelled) and ammeter in series with it<br>voltmeter in parallel across LED only | B1<br>B1<br>B1 | diode symbol + circle + at least one arrow pointing away |
| | c | | the resistor limits the current in the circuit (when the LED conducts)<br>otherwise it could overheat/burn out/be damaged/AW | B1<br>B1 | |
| | d | | in fig 4.3 the voltage range is from zero to maximum possible<br>in fig. 4.2 the resistance variation is small/AW<br>(so) in fig. 4.2 voltage variation across LED is small | B1<br>B1<br>B1 | **allow** 6.0 V<br>**accept** the LED is part of a potential divider<br>**accept** only at the top end of the range/AW |
| | | | **Total question 4** | **16** | |

**3** Fig. 3.1 shows how the resistance of a thermistor varies with temperature.

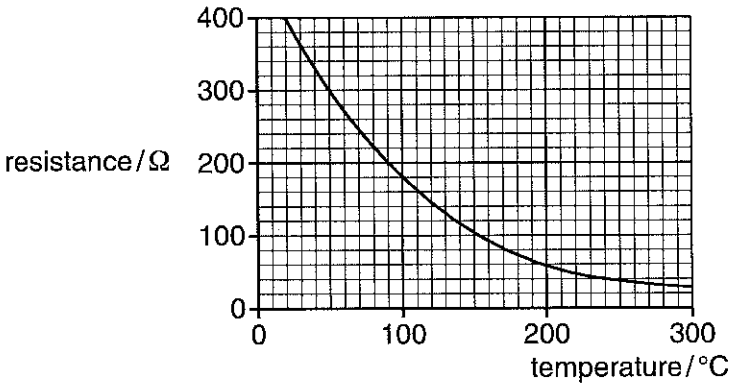


**Fig. 3.1**

The thermistor is used in the potential divider circuit of Fig. 3.2 to monitor the temperature of an oven. The 6.0 V d.c. supply has zero internal resistance and the voltmeter has infinite resistance.

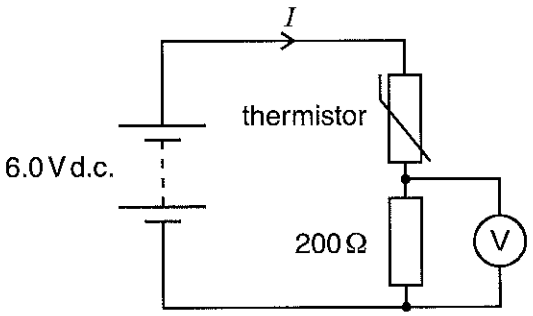


**Fig. 3.2**

**(a)** State and explain how the current $I$ in the circuit changes as the thermistor is heated.

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**(b)** Use Fig. 3.1 to calculate the voltmeter reading when the temperature of the oven is 240 °C.

voltmeter reading = ..... V **[4]**

**(c)** A light-dependent resistor (LDR) is another component used in sensing circuits.

**(i)** Complete Fig. 3.3 with an LDR between **X** and **Y**.

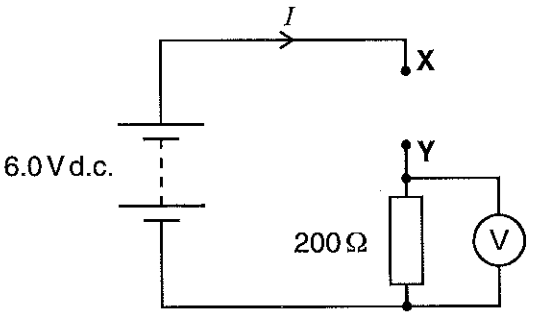


**Fig. 3.3**

**[1]**

**(ii)** State with a reason how the voltmeter reading varies as the intensity of the light incident on the LDR increases.

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..... **[2]**

**[Total: 10]**

| Question | | | Answer | Marks | Guidance |
|---|---|---|---|---|---|
| 3 A A A | (a) | | R <u>of thermistor</u> decreases as temperature increases<br>supply V is constant/ <u>total</u> R is smaller<br>current increases <u>as V = IR</u>/AW | B1<br>B1<br>B1 | **accept** more free e's as temperature rises<br>using I = nAev<br>current increases as v decrease very small/AW |
| | (b) | | $R_{th}$ = 40 Ω at 240 °C (stated or used in calculation)<br>total R in circuit = 240 Ω<br>I = 6/240 = 0.025 A<br>V = 200 x 0.025 = 5.0 V | B1<br>C1<br>C1<br>A1 | **apply ecf** if wrong value of R read from graph<br><br>**allow** V = (200/240)6<br>so V = 5.0 V **accept** 5 V (no SF error) |
| | (c) | (i) | correct symbol for LDR | B1 | no circle required |
| | | (ii) | R <u>of LDR</u> decreases/current in circuit increases<br>so V increases <u>across fixed/200 Ω resistor</u>/AW | M1<br>A1 | <br>**accept** simple potential divider argument<br>**accept** voltmeter reading increases |
| | | | **Total** | 10 | |

3 This question is about the use of a light-dependent resistor (LDR) as a light sensor in a potential divider circuit. Fig. 3.1 shows how the resistance of a particular LDR varies with light intensity.

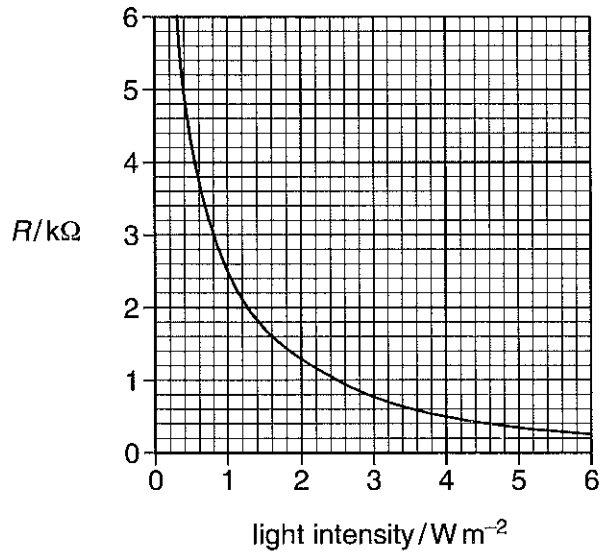


**Fig. 3.1**

**(a)** Explain the term *intensity*.

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..... **[1]**

**(b)** The intensity of daylight is about $10\,W\,m^{-2}$ and at night time is about $0.1\,W\,m^{-2}$. Describe how the resistance of the LDR changes during the day compared with how it changes at night.

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**(c)** Fig. 3.2 shows a light-sensing potential divider circuit where the LDR is connected in parallel to the input of an electronic circuit that operates a 230 V mains lamp.

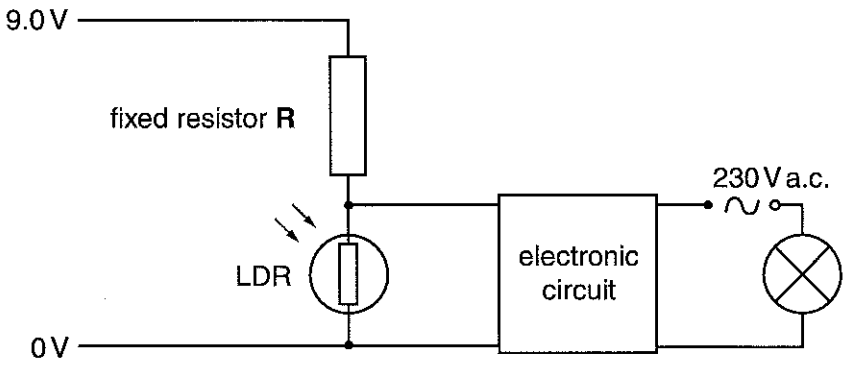


**Fig. 3.2**

The electronic circuit draws a negligible current. The potential difference across the LDR must be at least 5.0V to activate the circuit and switch on the lamp. The lamp is switched on when the light intensity falls to $1.0\,W\,m^{-2}$.

**(i)** Use Fig. 3.1 to determine the resistance of the LDR at a light intensity of $1.0\,W\,m^{-2}$.

resistance = ..... kΩ **[1]**

**(ii)** Calculate the current in the LDR in Fig. 3.2 for the p.d. across it to be 5.0V.

current = ..... A **[2]**

**(iii)** Show that the resistance of the fixed resistor **R** in Fig. 3.2 is 2.0kΩ.

**[1]**

**(d)** The lamp switches off when the light intensity reaches $2.5\,W\,m^{-2}$. Calculate the p.d. across the LDR when this happens.

potential difference = ..... V **[3]**

**(e)** Explain why the LDR must be shielded or be at some distance from the lamp when it switches on.

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..... **[2]**

**[Total: 12]**

| Question | | | Expected Answers | M | Additional Guidance |
|---|---|---|---|---|---|
| 3 | | | | | |
| | a | | energy per unit area per unit time | B1 | **accept** power per unit area; **allow** second for unit time |
| | b | | Small changes in R for high light intensities/daylight conditions<br>Large changes in R for low light intensities/dim light/night time conditions<br>to change circuit state need a significant change in R to be useful/reliable | B1<br><br>B1<br><br>B1 | **accept** low R by day, high R by night for 1 mark<br>**NOT** comparison e.g. R by day smaller than R at night<br><br>**max 2 marks** from 3 marking points |
| | c | i | 2.5 (kΩ) | A1 | **allow** 2.4 to 2.6 |
| | | ii | 5.0 = I x 2.5 kΩ<br>giving I = 2.0 x $10^{-3}$ A | C1<br>A1 | **ecf (c)(i)**<br>**accept** 2.0 mA |
| | | iii | 4.0 = 2.0 x $10^{-3}$ x R **or** potential divider argument<br>giving R = 2.0 x $10^{3}$ Ω | M1<br>A0 | **ecf (c)(ii) or ecf (c)(i)**<br>**accept** 2.0 kΩ |
| | d | | R (of LDR) = 1(.0 kΩ)<br>potential divider of 1.0 kΩ and 2.0 kΩ<br>giving 3.0 V across LDR | B1<br>C1<br>A1 | <br>**accept** I = 3.0 (mA)<br>so V = 3.0 (mA) x 1.0 (kΩ) = 3.0 V |
| | e | | light shining on the LDR will cause it to switch the illumination off<br>causing an ON/OFF oscillation/AW | B1<br>B1 | two suitable qualifying statements for the 2 marks |
| | | | **Total question 3** | **12** | |

**5** **(a)** The circuit in **Fig. 5.1** consists of a d.c. supply of e.m.f. 45 V and negligible internal resistance and three resistors.

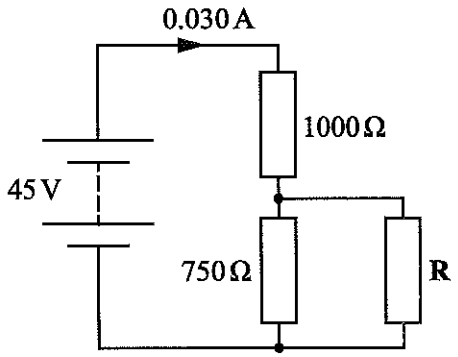


**Fig. 5.1**

Two of the resistors have resistances 1000 Ω and 750 Ω as shown.

The current drawn from the supply is 0.030 A. Calculate the resistance of **R**.

resistance = ..... Ω **[4]**

**(b)*** Students are given a light dependent resistor (LDR) and asked to design a circuit for a light meter to monitor changes in light intensity. The meter reading must rise when the light intensity increases.

The incident light may cause the resistance of the LDR to vary between 1500 Ω and 250 Ω.

The students are asked to use the d.c. supply and one of the resistors from **(a)** above and either a voltmeter or ammeter.

Draw a suitable circuit.

Explain why the reading on the meter increases with increasing light intensity and which of the three fixed resistors gives the largest scale change on the meter for the change in light intensity.

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..... **[6]**

| Question | | | Answer | Marks | Guidance |
|---|---|---|---|---|---|
| 5 | (a) | | V across 750 Ω = 45 - 0.03 x 1000 = 15 (V)<br><br>current in 750 Ω = 15/750 = 0.02 (A)<br><br>current in **R** = 0.01 (A)<br><br>R = 15/0.01 = 1500 (Ω) | C1<br><br>C1<br><br>C1<br><br>A1 | several methods available,<br>e.g.<br>find the total resistance = 45/0.03 = 1500 (Ω)<br>resistance of parallel pair = 500 (Ω)<br>$R=(500^{-1} - 750^{-1})^{-1}$ = 1500 (Ω)<br><br>or use potential divider argument. |
| | (b)* | | **Level 3 (5–6 marks)**<br>Circuit including meter is correctly drawn.<br>Explanation of action of circuit is correct.<br>Concept of sensitivity understood and 750 Ω justified<br>(6 marks)<br><br>LDR wrong symbol or value of resistor not fully justified (5 marks).<br>*There is a well-developed line of reasoning which is clear and logically structured. The information presented is relevant and substantiated.*<br><br>**Level 2 (3–4 marks)**<br>Circuit has correct symbol for LDR<br>Action of circuit explanation limited<br>750 Ω stated but not justified<br>Concept of sensitivity<br>(4 marks)<br><br>Any point omitted or incorrect (3 marks).<br>*There is a line of reasoning presented with some structure. The information presented is in the most-part relevant and supported by some evidence.* | B1<br>x6 | **circuit diagram**<br>1. resistor and LDR in series<br>2. ammeter in series or voltmeter in parallel with resistor<br>3. correct symbols for LDR, ammeter, voltmeter, etc.<br><br>**action of circuit**<br>1. when light intensity increases R of LDR falls<br>2. so I in circuit increases or V across resistor increases or *V* across LDR decreases (meter reading increases).<br><br>**meter and sensitivity**<br>1. need the largest change in current or voltage for a given change in light intensity<br>2. choose resistor of 750 Ω to give the largest change on the meter **or** need a meter which can display small changes in value of current or voltage. |

| Question | | | Answer | Marks | Guidance |
|---|---|---|---|---|---|
| | | | **Level 1 (1–2 marks)**<br>Correct symbol for LDR (1 mark)<br>Action of circuit only addresses point (1 mark)<br>Sensitivity poorly addressed (1 mark)<br>(Maximum 2 marks)<br><br>*The information is basic and communicated in an unstructured way. The information is supported by limited evidence and the relationship to the evidence may not be clear.*<br><br>**0 marks**<br>No response or no response worthy of credit. | | |
| | | | **Total** | **10** | |