

## OCR A AS Potential Dividers and Sensor Circuits worksheet

35–40 minutes independent practice + 15–20 minutes review | 41 marks

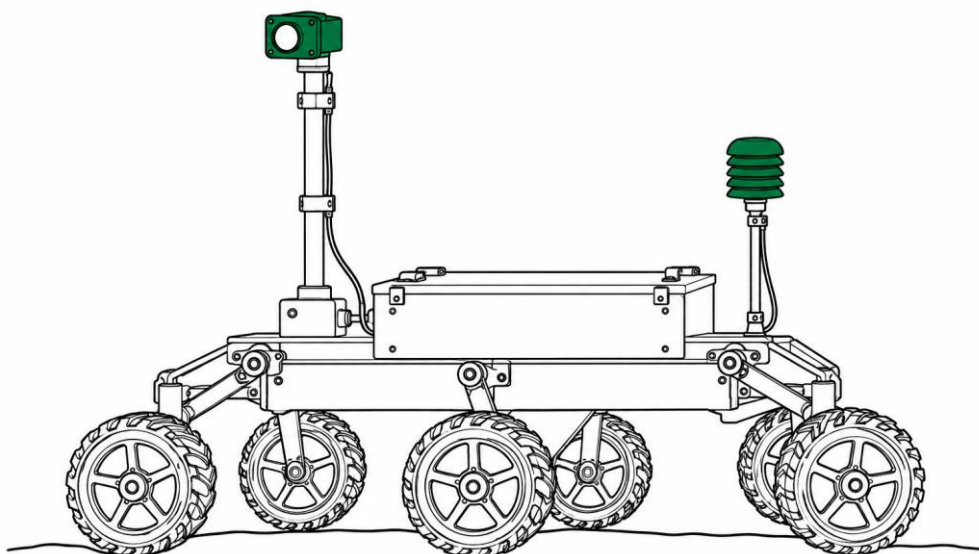
### Specification points covered

- 4.3.3(a) Describe potential divider circuits with fixed components and potentiometers.
- 4.3.3(b) Describe potential divider circuits with variable components such as LDRs or thermistors.
- 4.3.3(c)(i) Use  $V_{\text{out}} = [R_2/(R_1 + R_2)]V_{\text{in}}$  and  $V_1/V_2 = R_1/R_2$ .
- 4.3.3(c)(ii) Use techniques and procedures to investigate potential divider circuits including sensors.

### Kestrel lava tube exploration rover

Kestrel explores volcanic caves using adjustable reference voltages, an LDR entry sensor and an NTC thermistor that protects its electronics bay.

Calculate, explain and design the rover's sensor outputs, then plan a laboratory calibration of the thermistor divider.



Context diagram: the Kestrel rover and its light and temperature sensing systems.

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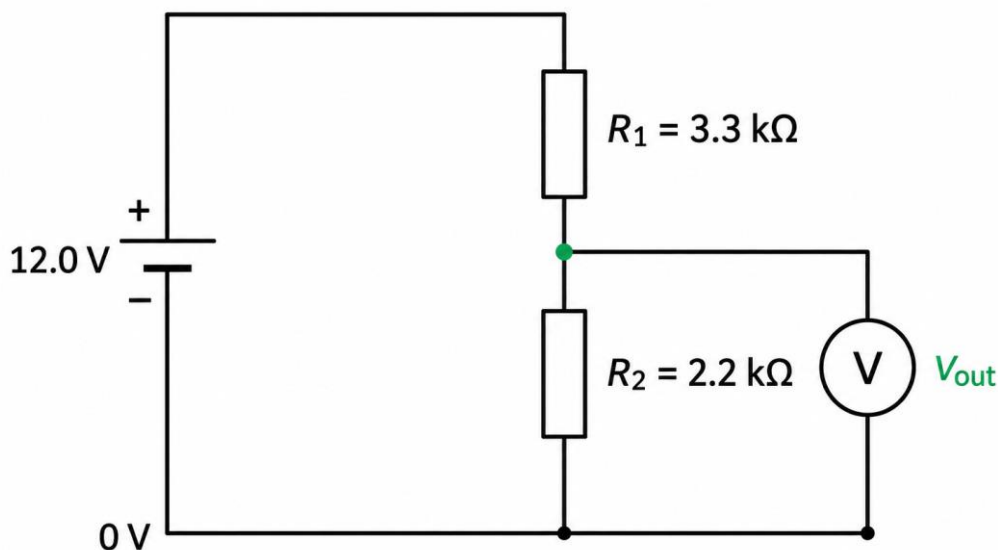
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## 1 Fixed potential dividers

1. The diagram shows a fixed potential divider on the rover's calibration panel. Calculate  $V_{\text{out}}$  and the p.d. across  $R_1$ . [2 marks]



*Fixed potential divider: the voltmeter is connected across  $R_2$ .*

2. Calculate the current through  $R_1$  and  $R_2$  in the circuit in Question 1. [1 mark]

3. The engineers keep  $R_1 = 3.3 \text{ k}\Omega$  but require  $V_{\text{out}} = 7.20 \text{ V}$  from the  $12.0 \text{ V}$  supply. Calculate the required value of  $R_2$ . [2 marks]

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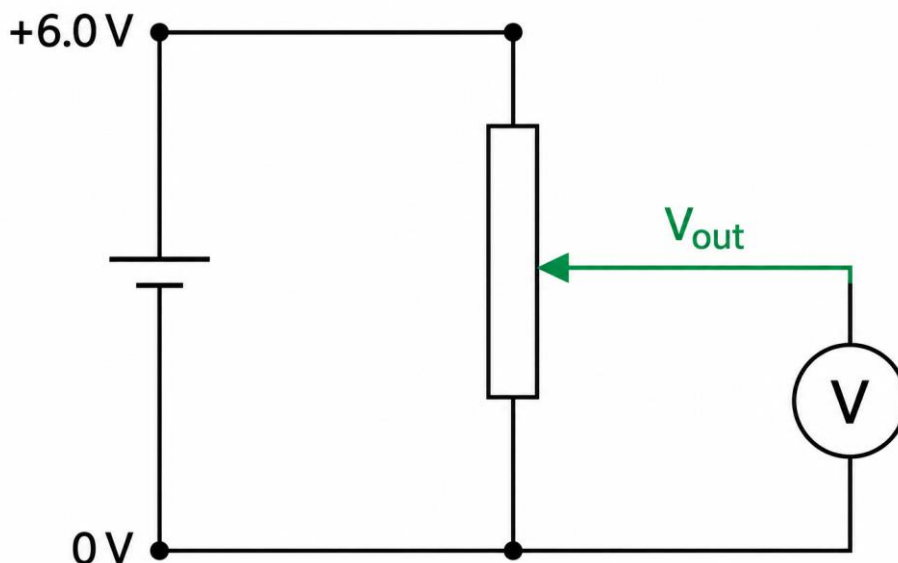
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## 2 Potentiometer control

4. The rover uses the potentiometer shown to set a reference voltage. State  $V_{\text{out}}$  when the wiper is at the midpoint. Explain why moving the wiper allows  $V_{\text{out}}$  to vary continuously from approximately 0 V to 6.0 V. [2 marks]



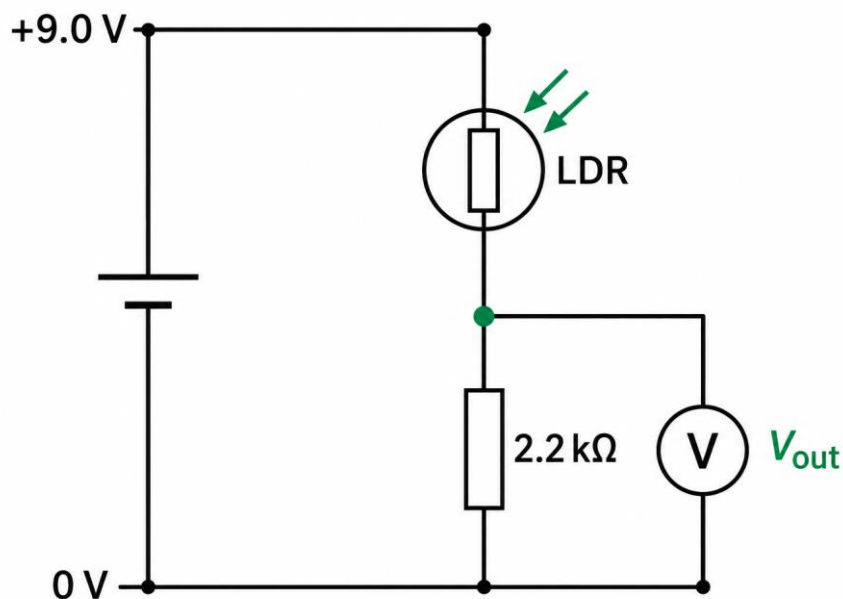
Potentiometer divider:  $V_{\text{out}}$  is measured between the wiper and 0 V.

5. The potentiometer track has total resistance 10.0 k $\Omega$ . The wiper is 25% of the track length from the +6.0 V end. Calculate  $V_{\text{out}}$  measured from the wiper to 0 V. [1 mark]



### 3 Cave entry light sensor

6. The diagram and table describe the rover's cave-entry light sensor. Calculate  $V_{\text{out}}$  when the rover is in very dark conditions. [2 marks]



Light sensor: the LDR is the upper component and  $V_{\text{out}}$  is across the lower fixed resistor.

| Lighting condition     | LDR resistance / $k\Omega$ |
|------------------------|----------------------------|
| Very dark              | 18.0                       |
| Bright inspection lamp | 0.680                      |

7. Calculate  $V_{\text{out}}$  when the inspection lamp shines brightly on the LDR. State whether  $V_{\text{out}}$  increases or decreases compared with Question 6. [2 marks]

8. Without simply quoting the potential-divider equation, explain why  $V_{\text{out}}$  increases when more light reaches the LDR. [3 marks]

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#### 4 Selecting and reversing the light sensor

9. The controller must receive  $V_{\text{out}}$  greater than 6.0 V in bright light but less than 1.0 V in very dark conditions. The available fixed resistors are 1.0 k $\Omega$ , 2.2 k $\Omega$  and 4.7 k $\Omega$ . Select the resistor that meets both conditions and justify your choice with calculations. [3 marks]

10. The LDR and fixed resistor are exchanged, and  $V_{\text{out}}$  is now measured across the LDR. Describe and explain how  $V_{\text{out}}$  changes when the light intensity increases. [2 marks]

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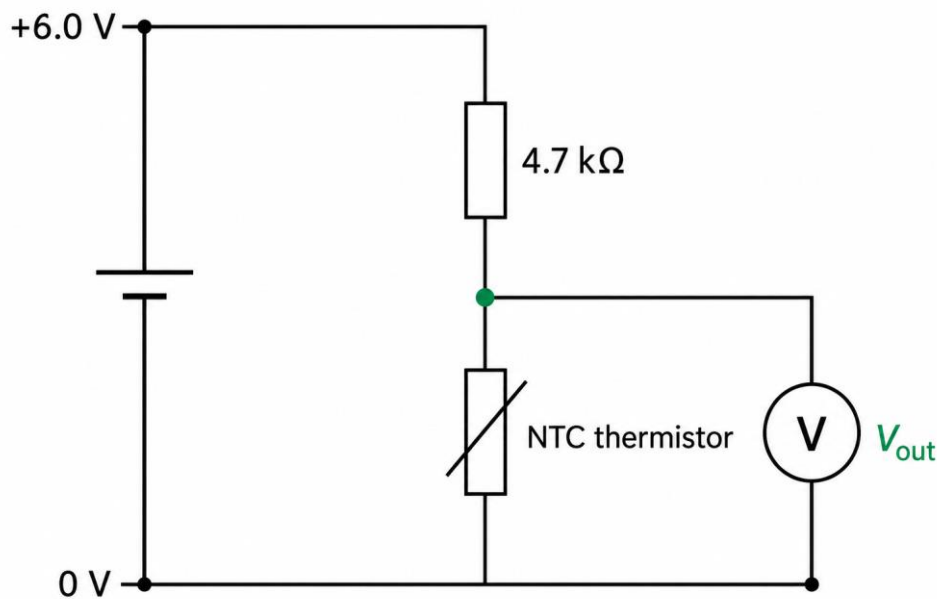
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5 Electronics bay temperature sensor

11. The diagram and table describe the electronics-bay temperature sensor. Calculate  $V_{out}$  at 20 °C and at 60 °C. [2 marks]



Temperature sensor:  $V_{out}$  is measured across the lower NTC thermistor.

| Temperature / °C | NTC resistance / kΩ |
|------------------|---------------------|
| 20               | 12.0                |
| 30               | 8.0                 |
| 40               | 4.7                 |
| 50               | 3.0                 |
| 60               | 2.0                 |

12. The controller activates a cooling fan when  $V_{out}$  falls to 3.0 V. Use the divider equation and the table to determine the activation temperature. [2 marks]

13. Explain why  $V_{out}$  falls as the temperature of the NTC thermistor rises. Refer to resistance, current or voltage sharing in your answer. [3 marks]



## 6 Setting a temperature threshold

14. A different controller requires an output that increases as temperature rises. State how the thermistor and fixed resistor should be rearranged, and explain the resulting change in  $V_{\text{out}}$ . [2 marks]

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15. At 30 °C the NTC thermistor has resistance 8.0 k $\Omega$ . It is used as the upper component of a 6.0 V divider. Calculate the lower fixed resistance required to give  $V_{\text{out}} = 4.0$  V. [2 marks]

16. Engineers replace the lower fixed resistor in Question 15 with a potentiometer. Explain one advantage of this change and state what happens to  $V_{\text{out}}$  when the resistance below the wiper is increased. [2 marks]

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## 7 Investigating and calibrating a sensor divider

17. Before deployment, engineers investigate how  $V_{\text{out}}$  from an NTC-thermistor potential divider varies with temperature. Describe a complete method. Include a correctly connected circuit, how temperature is varied and measured, the readings taken, the graph plotted and steps used to improve reliability. [6 marks]

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18. Explain two precautions that reduce error caused by self-heating or thermal lag during the investigation in Question 17. [2 marks]

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### Review and improve

- ☐ I identify the component across which  $V_{\text{out}}$  is measured before choosing the equation numerator.
- ☐ I link light or temperature changes to sensor resistance and then to the divider output.
- ☐ I can draw and investigate a sensor potential divider using a correctly positioned voltmeter.

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