

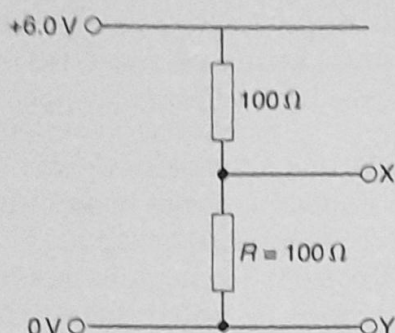
6.2

Circuits for measurement and sensing

In this section you will need to

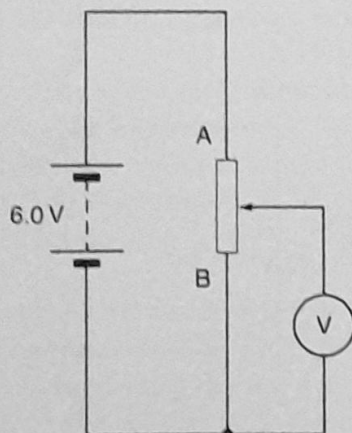
- know how to connect an ammeter and a voltmeter in a circuit to measure current and p.d.
- describe how to measure the resistance and power of a resistor
- understand how a rheostat can be used as a current limiter, using two terminals
- understand how a rheostat can be used as a potential divider, using three terminals, and what the advantage of this is
- understand that thermistors and light-dependent resistors (LDRs) are sensors which can be used to control other devices
- understand how potential dividers can be used with sensors.

- 6.15** The circuit shows a potential divider arrangement using an 'input' voltage of 6.0 V.



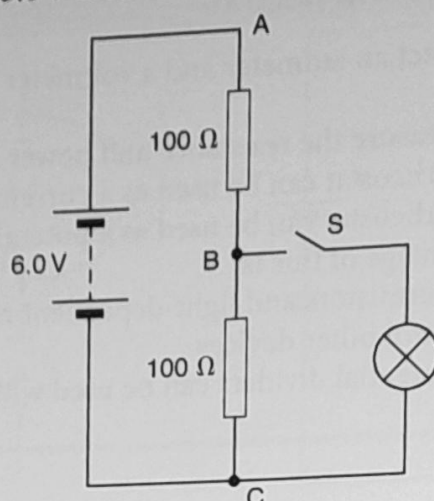
- (a) Calculate the 'output' voltage, i.e. the p.d. V_{out} between X and Y.
 (b) What will be the output voltage when separately (i) the input voltage is doubled to 12 V (ii) R is increased to $500\ \Omega$ (iii) R is increased to $2000\ \Omega$?

- 6.16** The diagram shows a potential divider in which a rheostat is connected to a p.d. of 6.0 V. A voltmeter is connected to measure the output voltage V_{out} as the slider bar is moved from end A to end B of the rheostat.



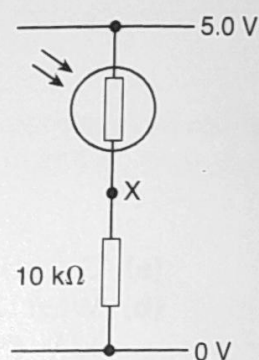
- (a) State and explain the readings of V_{out} when the rheostat slider is connected to (i) A (ii) B.
 (b) Sketch a graph of V_{out} against the position of the slider it moves from A to B.

- 6.17** The diagram shows a potential divider ABC where the output can be connected across a signal lamp labelled '3.0 V 0.25 A'

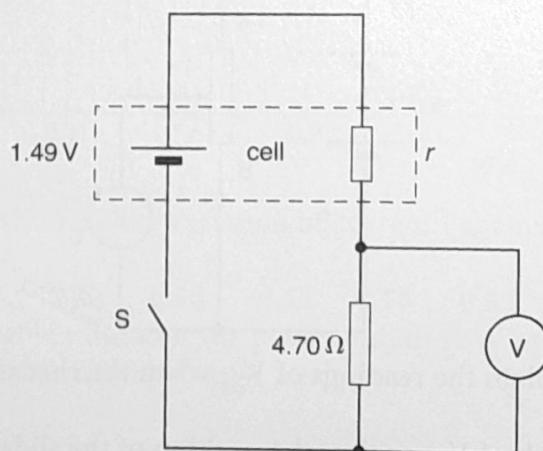


- (a) Show that the working resistance of the lamp is $12\ \Omega$.
 (b) Assuming the resistance of the lamp remains $12\ \Omega$, calculate, when the switch S is closed (i) the resistance between B and C (ii) the p.d. across the lamp.
 (c) Hence explain why the lamp will not then light.

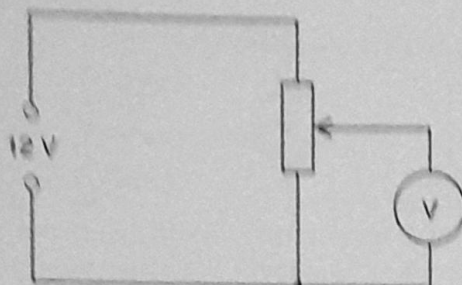
- 6.18** A light-dependent resistor and a fixed resistor (of resistance $10\ \text{k}\Omega$) are connected as shown in series between the terminals of a power supply which provides a constant p.d. of 5.0 V. The negative terminal of the power supply is earthed, i.e. may be taken to be 0 V. In the dark the potential of the point X is 0.21 V; when more light falls on the LDR the potential of X rises to 4.2 V. Calculate the resistance of the LDR in these two situations.



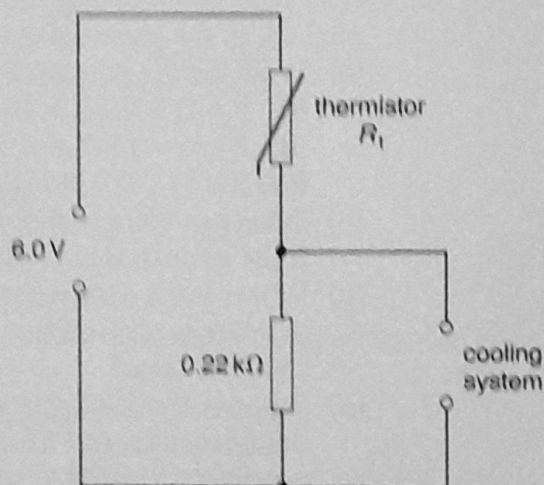
- 6.19** In order to measure the internal resistance r of a dry cell, a student connects it in series with a $4.70\ \Omega$ resistor and a switch S. She has already measured the e.m.f. of the cell to be 1.49 V. She now draws the circuit diagram as shown in order to stress that the internal and external resistors form a potential divider. On closing the switch she notes the voltmeter reading to be 1.41 V. What value does she deduce for r ?



- 6.20** A rheostat of maximum resistance $100\ \Omega$ is connected as a potential divider, as shown in the diagram, to a power supply which provides a constant p.d. of 12 V . The slider is moved until the voltmeter reads 3.0 V .
- Copy the diagram and show the position of the slider.
 - A $47\ \Omega$ resistor is now connected across the output of the potential divider, i.e. in parallel with the voltmeter. The voltmeter reading changes. Explain whether it rises or falls.
 - What is the new voltmeter reading?
 - Calculate the current in the power supply.
 - What is then the current in (i) the $47\ \Omega$ resistor (ii) the part of the rheostat in parallel with the $47\ \Omega$ resistor?

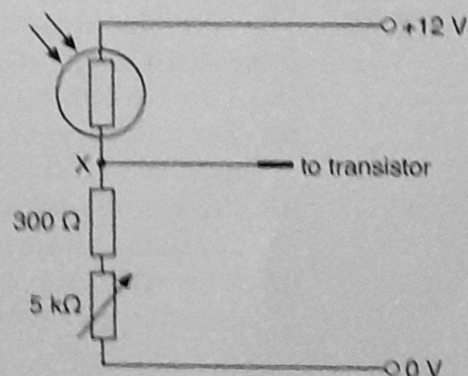


- 6.21*** The diagram shows a possible control circuit for a cooling system such as a refrigerator. The cooling system, which can be assumed to have infinite resistance, is switched on when the voltage across it rises above 3 V . At temperatures of $\theta/^\circ\text{C} = 0, 2, 4, 6$, the resistance of the thermistor is $R/\text{k}\Omega = 0.65, 0.32, 0.16, 0.10$.



- Calculate the p.d. V_x across the cooling system at each of these temperatures.
- Discuss whether this switching circuit can be used to switch on the cooling system in a domestic refrigerator when the temperature inside the fridge rises above 3°C .

- 6.22** The diagram shows a circuit in which an LDR is being used as a sensor. A lead at X is connected to a device called a transistor (not shown). When the potential at this point rises above about 0.7 V , the transistor 'turns on' and operates a relay which switches on a lamp.



- On a dull day, the resistance of the LDR is $500\text{ k}\Omega$, and the rheostat is set to provide maximum resistance in series with the fixed resistor of $300\ \Omega$.

- What is the potential at X?
- Is the transistor 'on'?

The resistance of an LDR decreases as the illumination increases.

- Calculate the resistance of the LDR when the transistor first turns on.
- Why is the rheostat included in the circuit?