# Sensing Devices

## Question paper 1

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|---|---|
| **Level** | International A Level |
| **Subject** | Physics |
| **Exam Board** | CIE |
| **Topic** | Current of Electricity |
| **Sub Topic** | Sensing Devices |
| **Paper Type** | Theory |
| **Booklet** | Question paper 1 |

**Time Allowed:** **66 minutes**

**Score:** **/55**

**Percentage:** **/100**

| A* | A | B | C | D | E | U |
|---|---|---|---|---|---|---|
| >85% | '77.5% | 70% | 62.5% | 57.5% | 45% | <45% |

**1** A thermistor has resistance 3900 Ω at 0 °C and resistance 1250 Ω at 30 °C. The thermistor is connected into the circuit of Fig. 8.1 in order to monitor temperature changes.

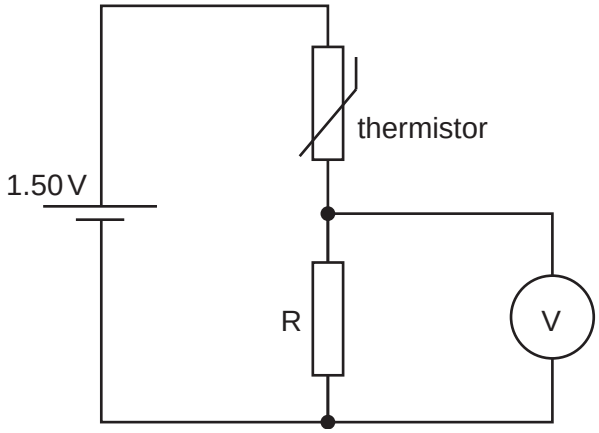


**Fig. 8.1**

The battery of e.m.f. 1.50 V has negligible internal resistance and the voltmeter has infinite resistance.

**(a)** The voltmeter is to read 1.00 V at 0 °C. Show that the resistance of resistor R is 7800 Ω.

[2]

**(b)** The temperature of the thermistor is increased to 30 °C. Determine the reading on the voltmeter.

reading = ..... V [2]

**(c)** The voltmeter in Fig. 8.1 is replaced with one having a resistance of 7800 Ω.
Calculate the reading on this voltmeter for the thermistor at a temperature of 0 °C.

reading = ..... V [2]

**2** **(a)** The strain in a beam is to be monitored using a strain gauge.
The strain gauge is included in the potential divider circuit shown in Fig. 9.1.

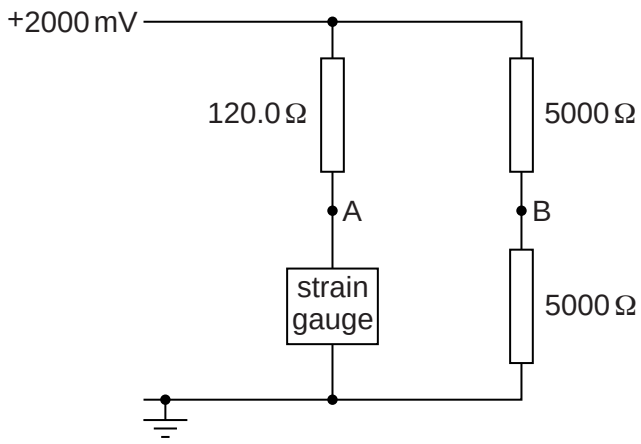


**Fig. 9.1**

The strain gauge has a resistance of 120.0 Ω when it is not strained. The resistance increases to 121.5 Ω when the strain is $\varepsilon$.

Calculate the potential difference between points A and B on Fig. 9.1 when the strain in the gauge is $\varepsilon$.

potential difference = ..... mV [3]

**(b)** An inverting amplifier, incorporating an operational amplifier (op-amp), uses a high-resistance voltmeter to display the output. A partially completed circuit for the amplifier is shown in Fig. 9.2.

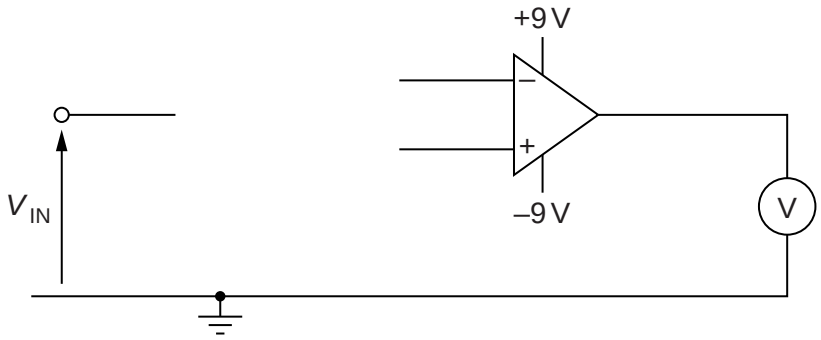


**Fig. 9.2**

The voltmeter is to indicate a full-scale deflection of +6.0V for an input potential $V_{IN}$ of 0.15V.

**(i)** On Fig. 9.2,

**1.** complete the circuit for the inverting amplifier, [2]

**2.** mark, with the letter P, the positive terminal of the voltmeter. [1]

**(ii)** Suggest appropriate values for the resistors you have shown in Fig. 9.2.
Label the resistors in Fig. 9.2 with these values. [2]

**3** **(a)** Suggest electrical sensing devices, one in each case, that may be used to monitor changes in

**(i)** light intensity,

.....[1]

**(ii)** the width of a crack in a welded joint,

.....[1]

**(iii)** the intensity of an ultrasound beam.

.....[1]

**(b)** A student designs the circuit of Fig. 9.1 to detect changes in temperature in the range 0 °C to 100 °C.

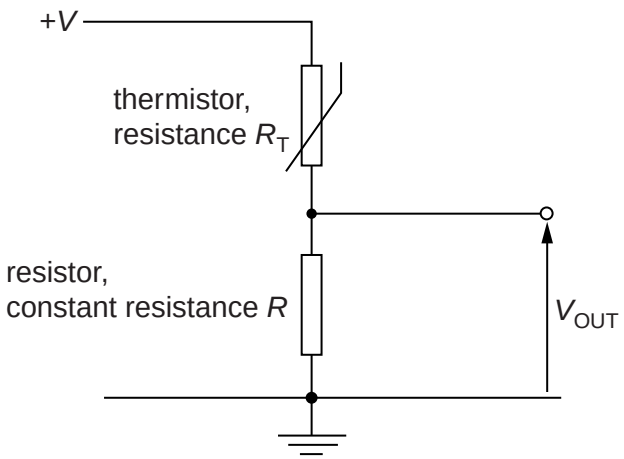


**Fig. 9.1**

The resistance of the thermistor is $R_T$ and that of the resistor is $R$.
The student monitors the potential difference $V_{OUT}$.

State and explain

**(i)** whether $V_{OUT}$ increases or decreases as the temperature of the thermistor increases,

.....

.....

.....

.....[3]

**(ii)** whether the change in $V_{OUT}$ varies linearly with the change in temperature of the thermistor.

.....

.....

.....

.....[2]

**4** The volume of fuel in the fuel tank of a car is monitored using a sensing device. The device gives a voltage output that is measured using a voltmeter. The variation of voltmeter reading with the volume of fuel in the tank is shown in Fig. 9.1.

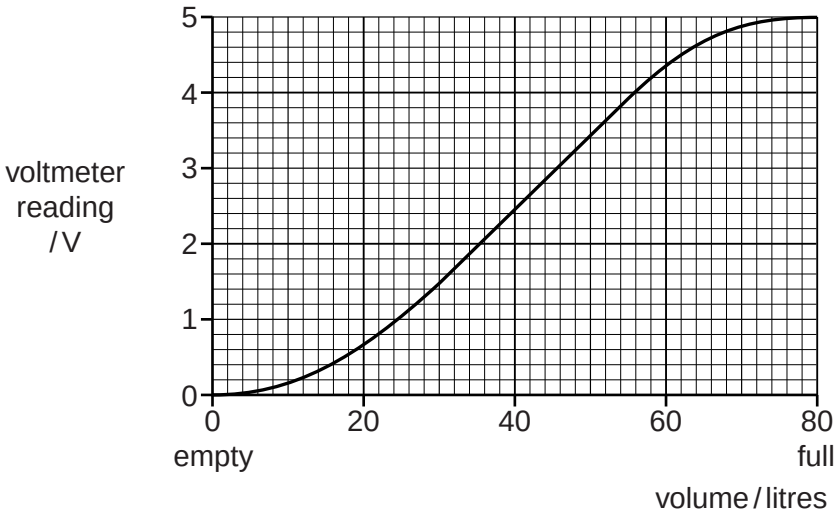


**Fig. 9.1**

**(a)** Use Fig. 9.1 to determine the range of volume over which the volume has a linear relationship to the voltmeter reading.

from ..... litres to ..... litres [1]

**(b)** Suggest why, comparing values from Fig. 9.1,

**(i)** when the tank is nearly full, the voltmeter readings give the impression that fuel consumption is low,

.....

.....

..... [2]

**(ii)** when the voltmeter first indicates that the tank is nearly empty, there is more fuel remaining than is expected.

.....

.....

..... [2]

**5** **(a)** The resistance of a light-dependent resistor (LDR) is approximately 500 Ω in daylight.
Suggest an approximate value for the resistance of the LDR in darkness.

resistance = ..... Ω [1]

**(b)** An electronic light-meter is used to warn when light intensity becomes low.
A light-dependent resistor is connected into the circuit of Fig. 9.1.

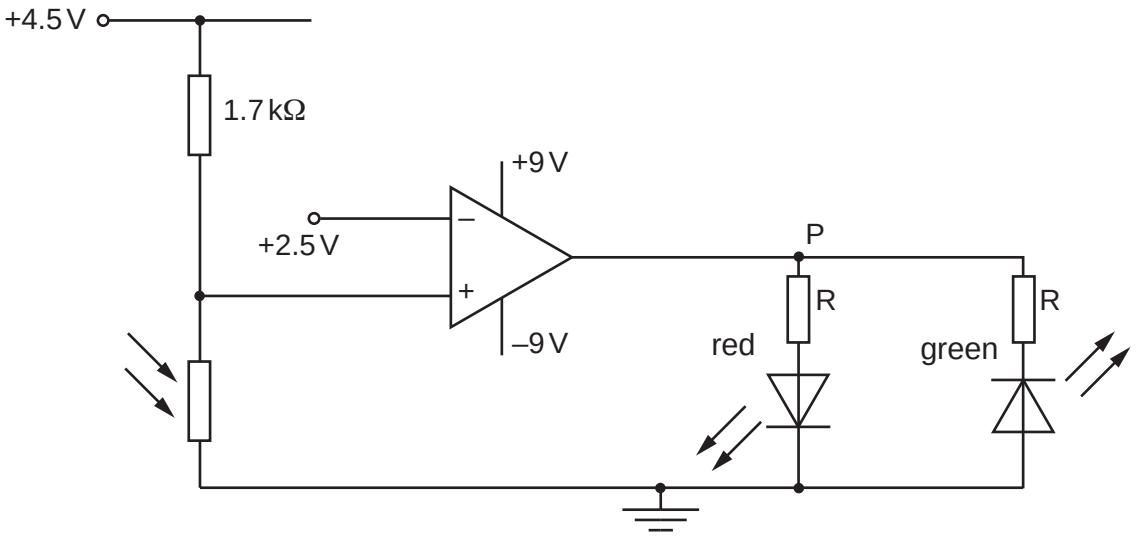


**Fig. 9.1**

The operational amplifier (op-amp) is ideal.
The resistors R are to ensure that the light-emitting diodes (LEDs) do not over-heat.

**(i)** On Fig. 9.1, mark the polarity of the point P for the red LED to be emitting light. [1]

**(ii)** The LDR is in daylight and has a resistance of 500 Ω.
State and explain which diode, red or green, will be emitting light.

.....

.....

.....

..... [3]

**(iii)** The intensity of the light decreases and the LDR is in darkness.
State and explain the effect on the LEDs of this change in intensity.

.....

.....

..... [2]

**6** **(a)** Describe the structure of a metal wire strain gauge. You may draw a diagram if you wish.

.....

.....

.....

..... [3]

**(b)** A strain gauge S is connected into the circuit of Fig. 9.1.

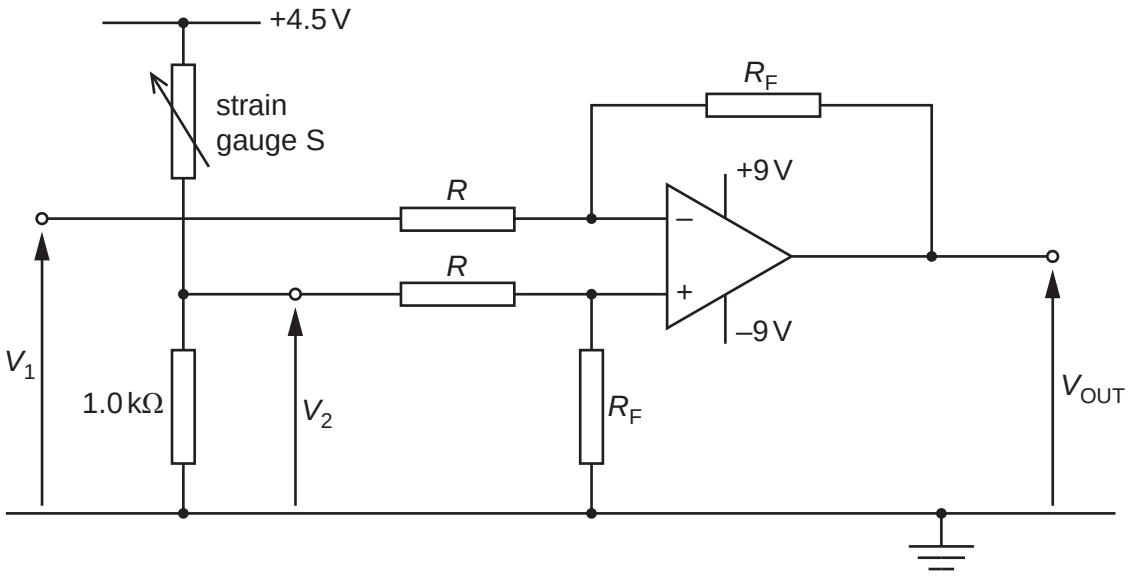


**Fig. 9.1**

The operational amplifier (op-amp) is ideal.
The output potential $V_{OUT}$ of the circuit is given by the expression

$$V_{OUT} = \frac{R_F}{R} \times (V_2 - V_1).$$

**(i)** State the name given to the ratio $\frac{R_F}{R}$.

..... [1]

**(ii)** The strain gauge S has resistance 125 Ω when not under strain.
Calculate the magnitude of $V_1$ such that, when the strain gauge S is not strained, the output $V_{OUT}$ is zero.

$V_1$ = ..... V [3]

**(iii)** In a particular test, the resistance of S increases to 128 Ω. $V_1$ is unchanged.
The ratio $\frac{R_F}{R}$ is 12.
Calculate the magnitude of $V_{OUT}$.

$V_{OUT}$ = ..... V [2]

**7** **(a)** State the name of an electrical sensing device that will respond to changes in

**(i)** length,

..... [1]

**(ii)** pressure.

..... [1]

**(b)** A relay is sometimes used as the output of a sensing circuit.

The output of a particular sensing circuit is either +2V or –2V.

On Fig. 10.1, draw symbols for a relay and any other necessary component so that the external circuit is switched on only when the output from the sensing circuit is +2V.


**Fig. 10.1**

[4]

**8** A metal wire strain gauge is firmly fixed across a crack in a wall, as shown in Fig. 9.1, so that the growth of the crack may be monitored.

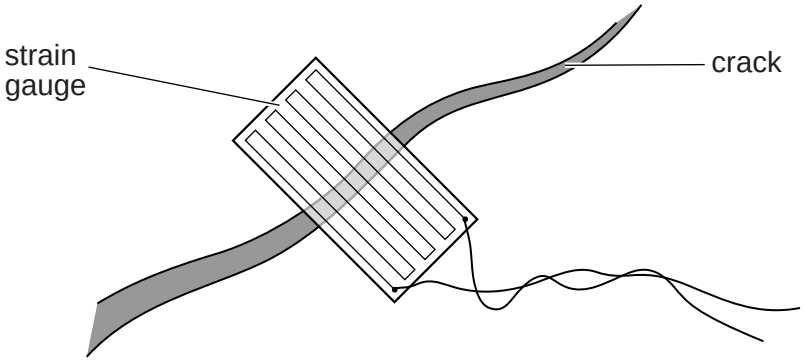


**Fig. 9.1**

**(a)** Explain why, as the crack becomes wider, the resistance of the strain gauge increases.

.....

.....

.....

..... [3]

**(b)** The strain gauge has an initial resistance of 143.0 Ω and, after being fixed in position across the crack for several weeks, the resistance is found to be 146.2 Ω.

The change in the area of cross-section of the strain gauge wire is negligible.

Calculate the percentage increase in the width of the crack. Explain your working.

increase = ..... % [3]