1 **(a)** Fig. 8.1 shows a circuit incorporating an ideal operational amplifier (op-amp).

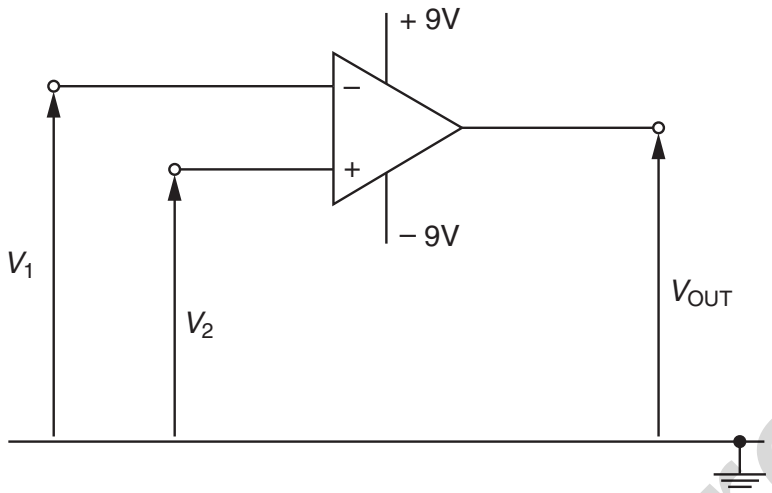


Fig. 8.1

The voltages applied to the inverting and the non-inverting inputs are V_1 and V_2 respectively.

State the value of the output voltage V_{OUT} when

(i) $V_1 > V_2$,

V_{OUT} = ... V

(ii) $V_1 < V_2$.

V_{OUT} = ... V
[1]

For Examiner's Use

(b) The circuit of Fig. 8.2 is used to monitor the input voltage V_{IN}.

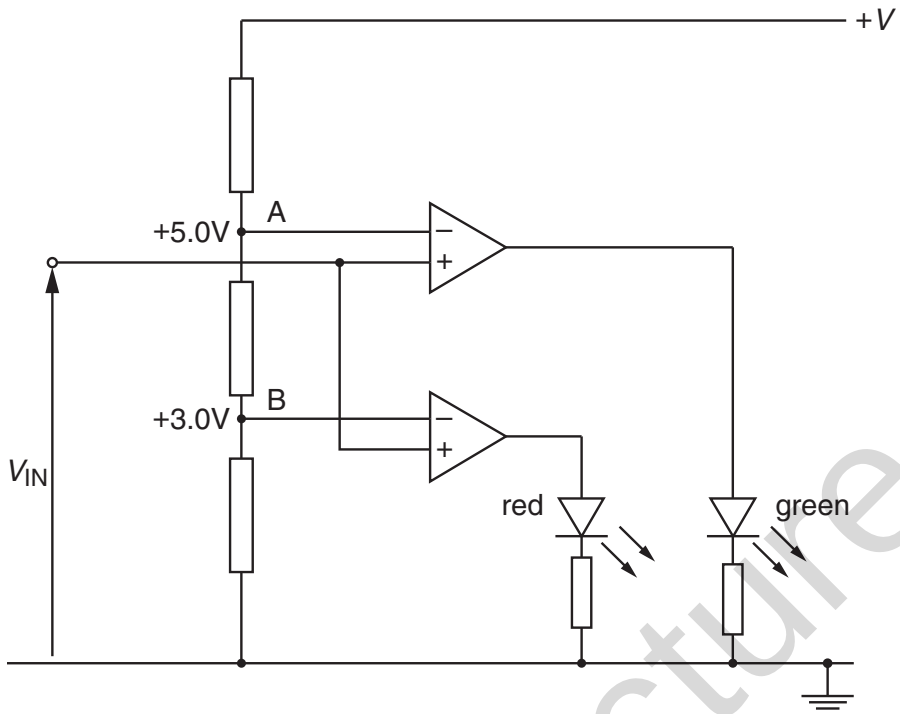


Fig. 8.2

At point A, a potential of 5.0V is maintained. At point B, a potential of 3.0V is maintained.

Complete Fig. 8.3 by indicating with a tick (✓) the light-emitting diodes (LEDs) that are conducting for the input voltages V_{IN} shown. Also, mark with a cross (✘) those LEDs that are not conducting.

V_{IN} / V	red LED	green LED
+2.0		
+4.0		
+6.0		

[3]

Fig. 8.3

(c) The input voltage V_{IN} in **(b)** is provided by a sensor circuit.

(i) Complete Fig. 8.4 to show a sensor circuit that will provide a voltage output that increases as the temperature of the sensor decreases. Show clearly the output connections from the circuit. [2]

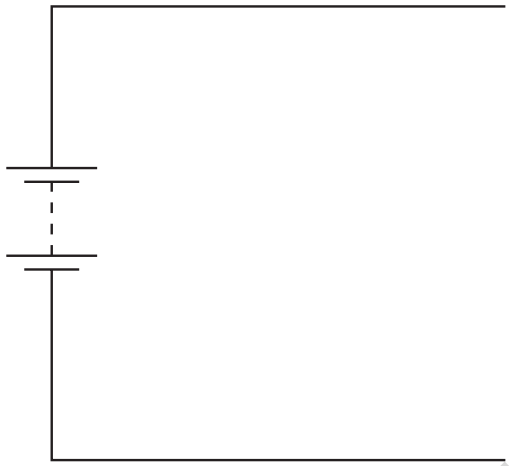


Fig. 8.4

(ii) Explain the operation of the sensor circuit.

.....

.....

.....

.....

.....

.....[3]

For Examiner's Use

2 (a) The circuit for an amplifier incorporating an ideal operational amplifier (op-amp) is shown in Fig. 10.1.

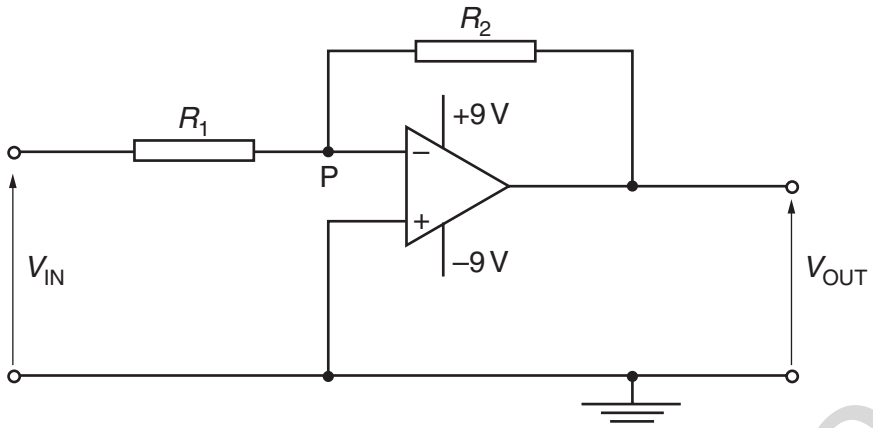


Fig. 10.1

(i) State

1. the name of this type of amplifier circuit,

.....[1]

2. why the point P is referred to as a *virtual earth*.

.....

.....

.....

.....[3]

(ii) Show that the gain G of this amplifier circuit is given by the expression

$$G = -\frac{R_2}{R_1}.$$

Explain your working.

[4]

For Examiner's Use

(b) The circuit of Fig. 10.1 is modified by connecting a light-dependent resistor (LDR) as shown in Fig. 10.2.

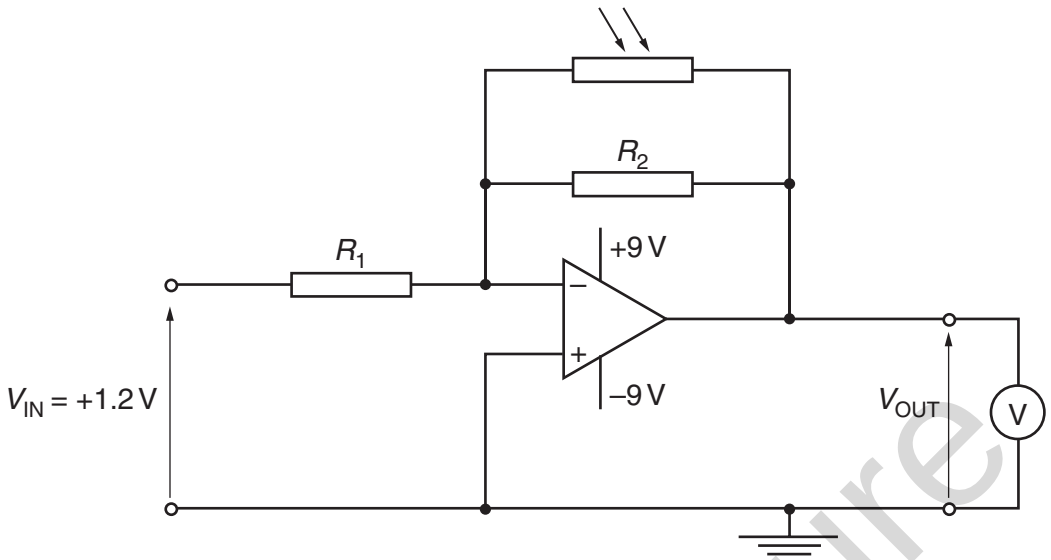


Fig. 10.2

The resistances R_1 and R_2 are 5.0 kΩ and 50 kΩ respectively.
The input voltage V_{IN} is +1.2V. A high-resistance voltmeter measures the output V_{OUT}.
The circuit is used to monitor low light intensities.

(i) Determine the voltmeter reading for light intensities such that the LDR has a resistance of

1. 100 kΩ,

reading = ... V [3]

2. 10 kΩ.

reading = ... V [2]

For Examiner's Use

(ii) The light incident on the LDR is provided by a single lamp. Use your answers in **(i)** to describe and explain qualitatively the variation of the voltmeter reading as the lamp is moved away from the LDR.

.....

.....

.....

.....

..... [3]

For Examiner's Use

3 **(a)** State three characteristics of an ideal operational amplifier (op-amp).

1. .....

2. .....

3. ..... [3]

(b) An amplifier circuit for a microphone is shown in Fig. 8.1.

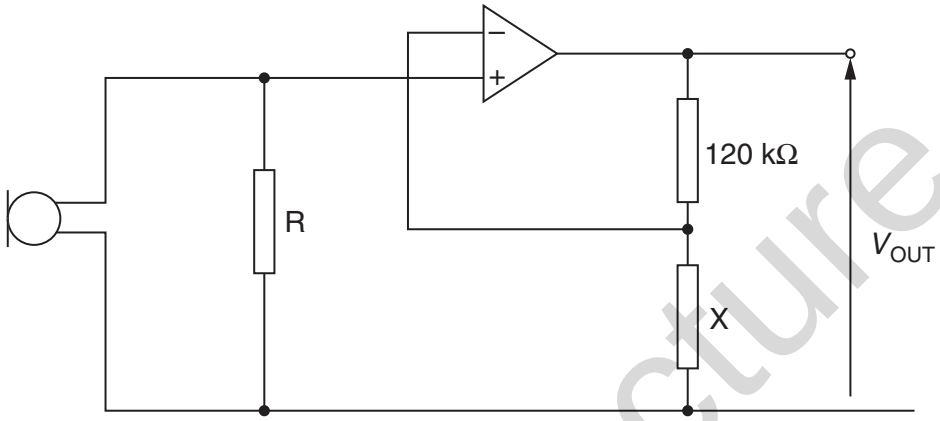


Fig. 8.1

(i) Name the type of feedback used with this op-amp.

..... [1]

(ii) The output potential difference V_{OUT} is 5.8V for a potential difference across the resistor R of 69 mV. Calculate

1. the gain of the amplifier circuit,

gain = ... [1]

For Examiner's Use

2. the resistance of resistor X.

resistance = ... Ω [2]

(iii) State one effect on the amplifier output of reducing the resistance of resistor X.

.....

..... [1]

For Examiner's Use

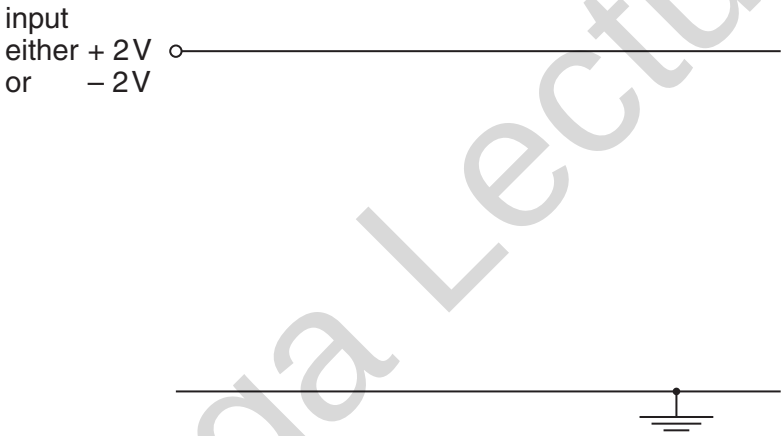
4 A block diagram for an electronic sensor is shown in Fig. 9.1.

Fig. 9.1

(a) Complete Fig. 9.1 by labelling the remaining boxes. [2]

(b) A device is to be built that will emit a red light when its input is at +2 V. When the input is at –2 V, the light emitted is to be green.

(i) On Fig. 9.2, draw a circuit diagram of the device.



[2]

Fig. 9.2

(ii) Explain briefly the action of this device.

.....

.....[1]

5 Outline briefly the main principles of the use of magnetic resonance to obtain information about internal body structures.

For Examiner's Use

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....[8]

For Examiner's Use

6 **(a)** Explain the principles behind the use of X-rays for imaging internal body structures.

.....

.....

.....

.....

.....

.....

..... [4]

(b) Describe how the image produced during CT scanning differs from that produced by X-ray imaging.

.....

.....

.....

.....

.....

.....

..... [5]

For Examiner's Use

7 **(a)** State what is meant by *acoustic impedance*.

.....

.....[1]

(b) Explain why acoustic impedance is important when considering reflection of ultrasound at the boundary between two media.

.....

.....

.....[2]

(c) Explain the principles behind the use of ultrasound to obtain diagnostic information about structures within the body.

.....

.....

.....

.....

.....

.....

.....

.....[5]

For Examiner's Use

8 (a) Distinguish between the images produced by CT scanning and X-ray imaging.

.....

.....

.....

.....[3]

(b) By reference to the principles of CT scanning, suggest why CT scanning could not be developed before powerful computers were available.

.....

.....

.....

.....

.....

.....

.....[5]

For Examiner's Use

9 An analogue signal is sampled at a frequency of 5.0 kHz. Each sample is converted into a four-bit number and transmitted as a digital signal.
Fig. 10.1 shows part of the digital signal.

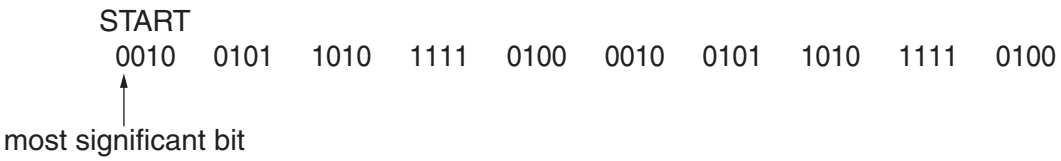
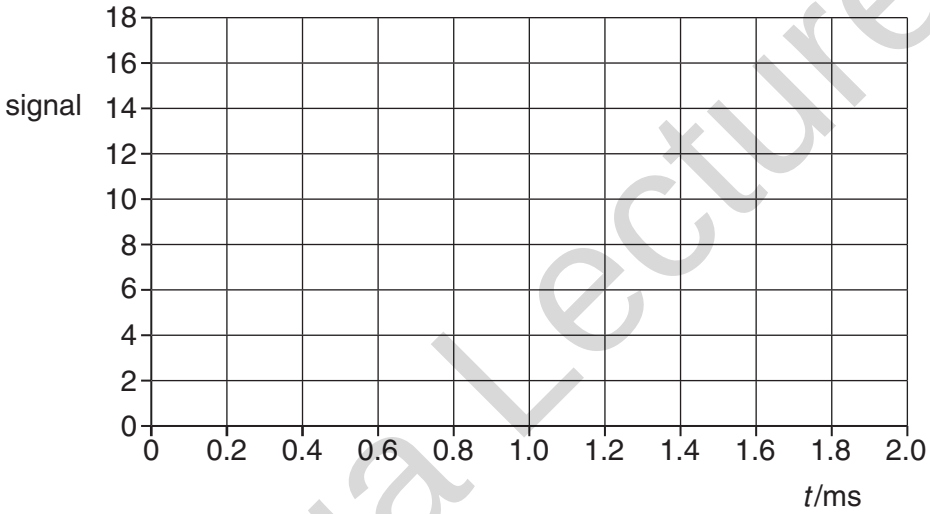


Fig. 10.1

The digital signal is transmitted and is finally converted into an analogue signal.

(a) On the axes of Fig. 10.2, sketch a graph to show the variation with time *t* of this final analogue signal.



[4]

Fig. 10.2

(b) Suggest two ways in which the reproduction of the original analogue signal could be improved.

1. .....

.....

2. .....

..... [2]