Access Tuition

A-Level Physics

Operational Amplifier

Mark Scheme

Time available: 52 minutes
Marks available: 45 marks

Mark schemes

1. (a) difference amplifier ✓

1

(b) $V_{out} = (V_+ – V_–) × (R_f / R_{in})$

V_{out} = (0 V – 150 mV) × (1 MΩ / 100 kΩ) ✓

V_{out} = –1.5 V ✓

1 mark for the correct resistor substitution / resistor ratio (10)

1 mark for −1.5 V (must have correct sign)

2

(c) Signal 2 is subtracted from signal 1 by the difference amplifier ✓

Noise is common to both so will be reduced / eliminated when subtracted ✓

Signals will also be subtracted resulting in an addition (re-enforcement) of the signal. ✓

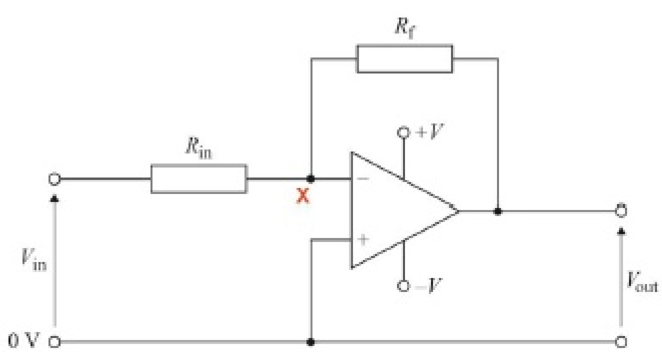
Accept arguments based on the 'phase' relationship

3

[6]

2.

(a)



Correct position of X:

1

(b) The non-inverting input

(non-inverting)

1

(c) $I = (V_{in} – V_x) / R_{in} = (V_x – V_{out}) / R_f$

But V_x = 0 V (a virtual earth)

$I = V_{in} / R_{in} = – V_{out} / R_f$

Making use of: $I_{in} = - I_F$

$$\frac{V_{out}}{V_{in}} = \frac{R_f}{R_{in}}$$

Making use of virtual earth concept

2

(d) Voltage gain (Channel 1) = – R_f / R_{in} 1

–(150 kΩ / 7.5 kΩ)

–20

*Both number **and** sign must be correct*

1

(e) V_{out} = – R_f ($V_{in\ Ch1}$ / R_1 + $V_{in\ Ch2}$ / R_2)

= – 150 kΩ ((15mV / 7.5kΩ) + (–100 mV / 30 kΩ))

= – ((0.3) + (–0.5)) = 0.2 Volts

Evidence of correct method

*Answer **and** correct sign*

1

(f) By using variable resistors

The gain can easily be changed
or
the relative levels of the two channels can be set
or
the required balance between the two signals can be made

One relevant point made

1

[6]

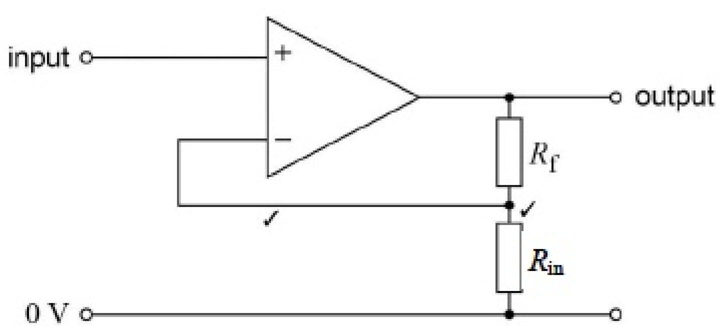
3. (a) Voltage in = Voltage out / Voltage gain

= 3 V / 40

= 75 × 10^{-3} V ✓

1

(b)



Two resistor chain, correctly labelled connected between output and ground

Inverting input connected to mid-point of resistor chain

2

(c) $\frac{V_{out}}{V_{in}} = 1 + \frac{R_f}{R_{in}}$

$40 = 1 + \frac{R_f}{R_{in}}$ calculation to give resistor ratio of 39 ✓

R_{in} = 1 kΩ ; R_f = 39 kΩ ✓

2

(d) Desired gain × bandwidth is 40 × 50 kHz = 2 MHz ✓

The Op Amp can only provide ½ the amplification needed. Not suitable. ✓

1 mark - relevant calculation

1 mark - reference to only providing ½ require amplification / gain so not suitable

2

[7]

4. (a) Formula, ✓
Substitution ✓
Gv=500 ✓

3

(b) Feedback resistor to output, ✓
Feedback resistor to – input, ✓
Resistor to + input, ✓
Resistor to 0V ✓

4

(c) Formula, ✓
substitution, ✓
1.1MΩ ✓

3

(d) (i) 2.2kΩ ✓

1

(ii) Voltage follower - Input to +, ✓
– to output ✓

2

[13]

5. (a) (i) A

(at inverting input)

1

(ii) a point on the circuit where the voltage is 0v / ground
but not connected to 0v / is almost 0v / simulates 0v
assuming that the op-amp has not saturated

2 max

(iii) 10kΩ (must have units unless 10,000 which assumes standard)

***oe** 10,000Ω / 10K etc*

1

(b) correct formula rearranged
calculation / substitution
470kΩ

3 for just correct answer with units

3

(c) inverted,
same frequency,
shape shows evidence of correct gain
maximum amplitude 3v to 5v

4

[11]