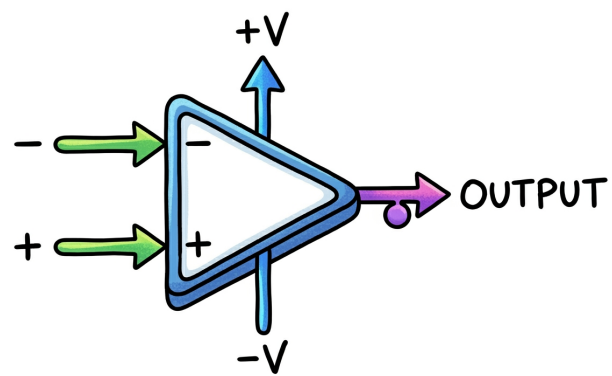


Topic 104 Operational Amplifiers Question Pack

for

Eduqas GCE A-Level Electronics



Student Name:

Class / Group:

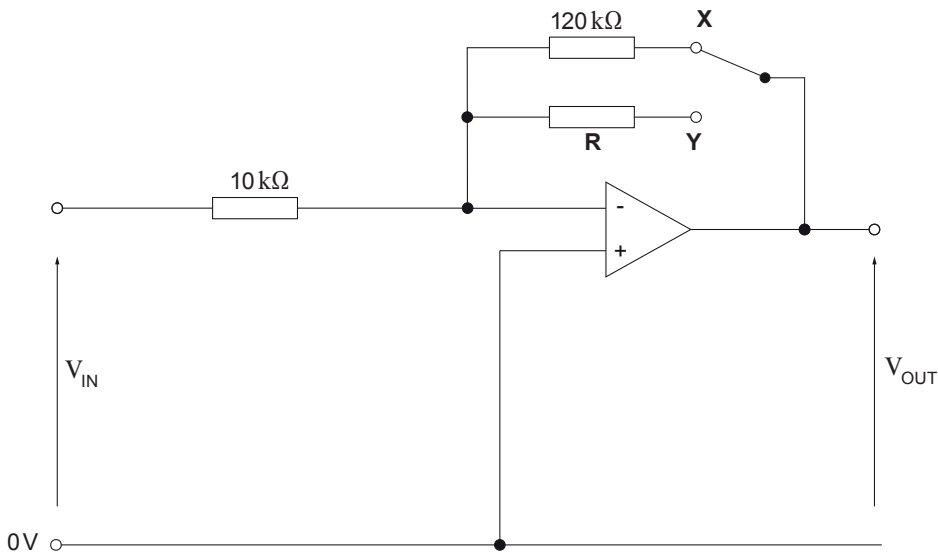
Question 1

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7. An extract from the data sheet of an op-amp is shown in the following table.

Parameter	Value
Input Impedance	10 MΩ
Output Impedance	100Ω
Open Loop Gain	10 ⁵
Gain Bandwidth Product	2.4 MHz
Slew Rate	5 Vμs ⁻¹

The circuit diagram shows the op-amp set up as a voltage amplifier. The switch allows the user to change the gain.



An input voltage of 0.8 V is applied to V_{IN} .
The op-amp is powered from a ± 16 V supply and saturation occurs at ± 15 V.

- (a) The switch is initially connected to point X. [5]
- (i) Calculate the voltage gain of the amplifier.

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- (ii) Calculate the output voltage when $V_{IN} = 0.8\text{ V}$.

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- (iii) Calculate the bandwidth of the amplifier.

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- (b) The switch is moved from **X** to **Y**. This **doubles** the voltage gain of the amplifier. [2]

- (i) Calculate the value of resistor **R**.

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- (ii) Determine the output voltage for $V_{IN} = 0.8\text{ V}$.

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- (c) State what change, **if any**, occurs to the following when the switch is moved from **X** to **Y**. [2]

- (i) The input impedance

- (ii) The bandwidth

- (d) Calculate the time it would take for the output voltage to change from -12 V to $+12\text{ V}$ in response to a large step change in input voltage. Show your working and give the appropriate unit. [3]

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Question 2

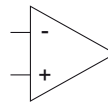
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8. (a) (i) Complete the circuit diagram for a non-inverting amplifier.

[3]

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Input ○ —



○ Output

0V ○ —————

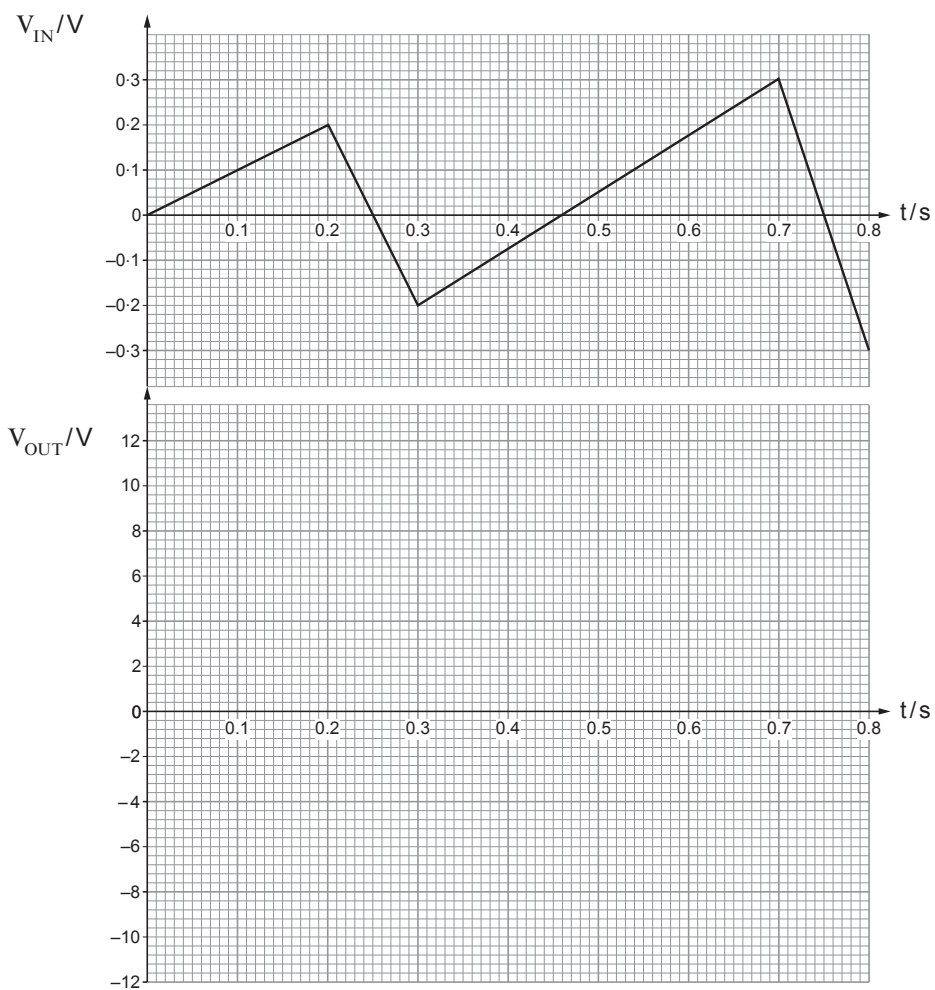
- (ii) Calculate component values to give a voltage gain of 40. Label the diagram with these values. [2]

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- (b) The upper graph shows a signal applied to the input of the voltage amplifier. Draw the output voltage on the axes provided. The op-amp is powered from a $\pm 12\text{ V}$ supply and saturation occurs at $\pm 11\text{ V}$. [4]

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END OF PAPER

Question 3

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6. The table shows some properties for two op-amps, S and T.

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Property	S	T
Input Impedance / Ω	5×10^8	4×10^9
Open loop gain	6×10^5	1×10^6
Maximum output current / mA	5	20
Gain bandwidth product / MHz	3.6	5.0
Slew rate / $V\mu s^{-1}$	6.0	4.5
Saturation voltage / V	± 18	± 18

- (a) (i) Explain which amplifier is capable of reaching its maximum output voltage in the **shortest** time when a large step input signal is applied. [1]

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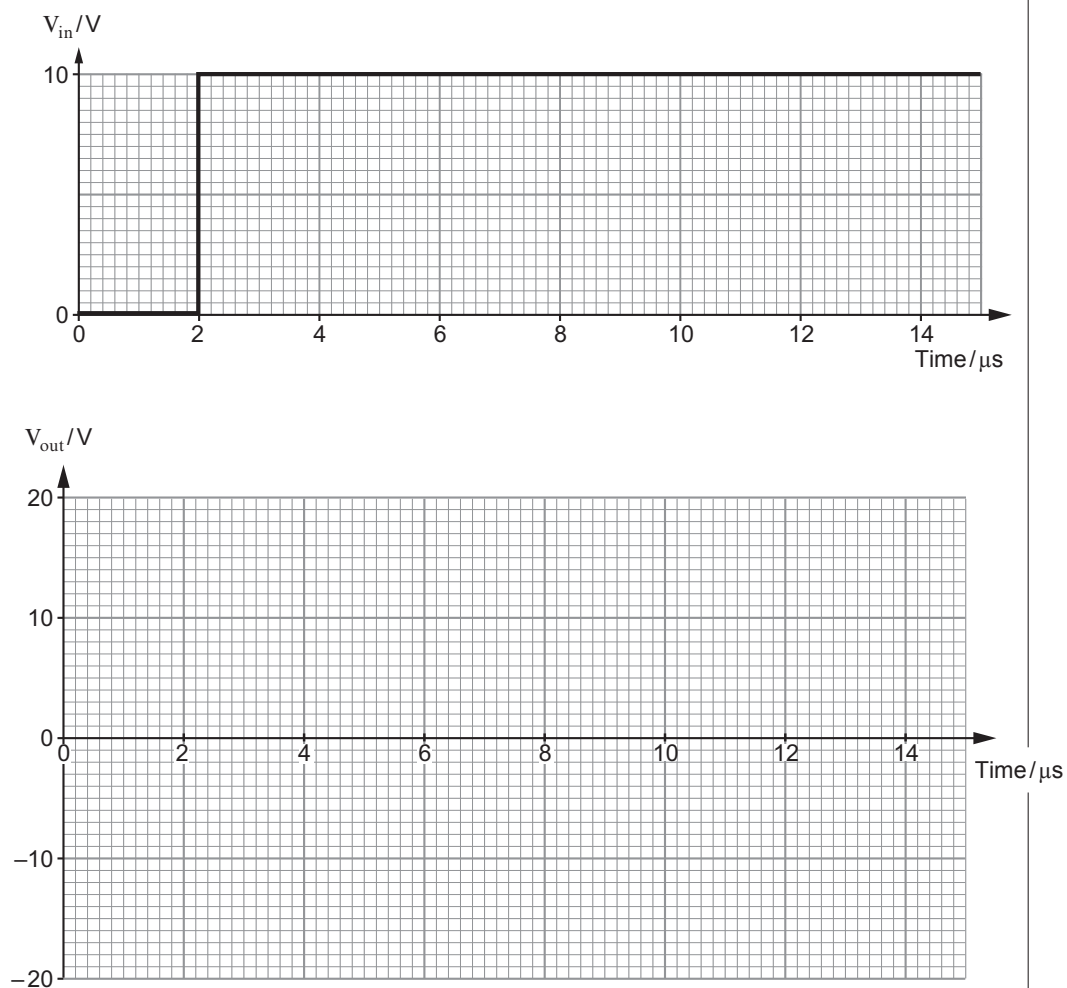
- (ii) Determine the bandwidth of amplifier S when configured to have a voltage gain of 400. [2]

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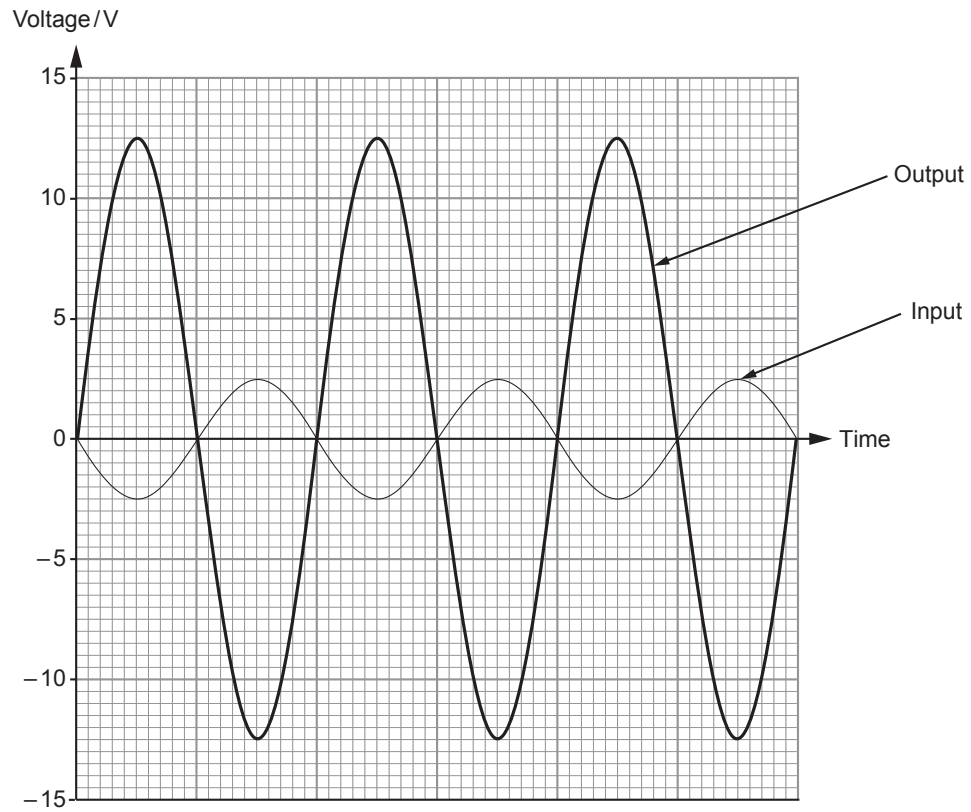
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- (b) Operational amplifier T is connected as an inverting voltage amplifier with a high gain. The following signal is applied to its input. Complete the graph to show the output voltage. The op-amp saturates at $\pm 18\text{ V}$. [3]

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- (c) Amplifier S is used to make a voltage amplifier. When tested the following input and output signals were produced.



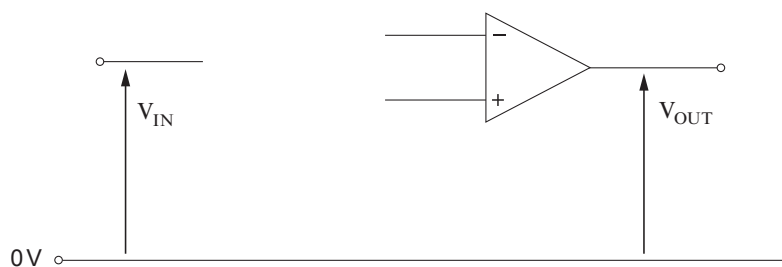
- (i) Use the graph to determine the voltage gain of the amplifier.

[1]

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- (ii) Complete the circuit diagram for an amplifier that would produce the graphs shown in part (c)(i). [3]



- (iii) Determine suitable component values to produce this voltage gain and label the circuit diagram. [2]

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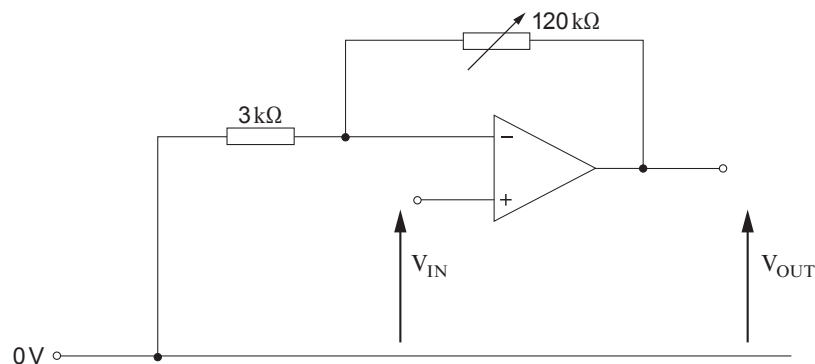
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Question 4

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7. The circuit diagram shows the op-amp set up as a voltage amplifier. The variable resistor allows the user to change the gain.

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The op-amp is powered from a $\pm 15\text{ V}$ supply and saturation occurs at $\pm 14\text{ V}$.

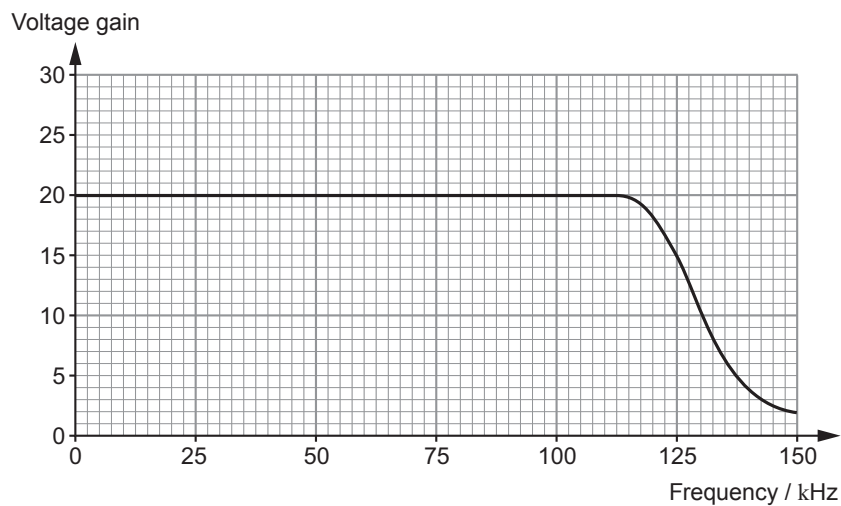
- (a) Calculate the maximum and minimum voltage gain of the amplifier.

[2]

Maximum gain = ...

Minimum gain = ...

The variable resistor is adjusted and the following frequency response graph is produced.



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- (b) Use the graph to determine the bandwidth at this setting of the variable resistor. [2]

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- (c) The variable resistor is adjusted again to give a voltage gain of 30. Determine the maximum input voltage that can be applied that avoids clipping. [2]

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- (d) The variable resistor is now reduced in value. State the effect this has on: [3]

- (i) The voltage gain of the amplifier.

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- (ii) The input voltage at which the amplifier just saturates.

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- (iii) The gain-bandwidth product of the amplifier.

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END OF PAPER

Question 5

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6. (a) Ideal operational amplifiers have some characteristics that should be either infinite or zero. Complete the table below by putting either **infinite** or **zero** to indicate the desired value. [2]

Characteristic	Infinite or zero
Open loop gain	
Input impedance	
Output impedance	
Slew-rate	

- (b) Practical voltage amplifiers should have a very high gain-bandwidth product.

- (i) Define bandwidth for a voltage amplifier. [1]

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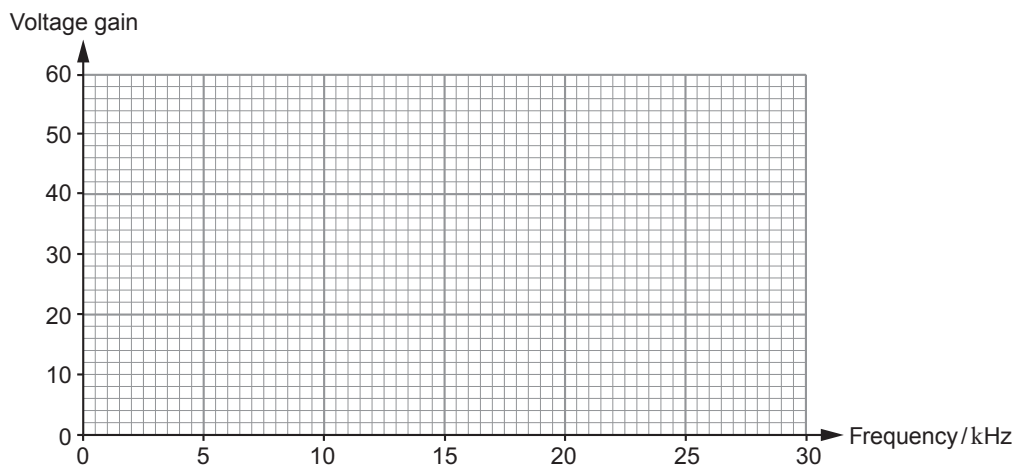
- (ii) A voltage amplifier with a gain-bandwidth product of 3 MHz is configured to have a voltage gain of 500. Calculate the bandwidth. [1]

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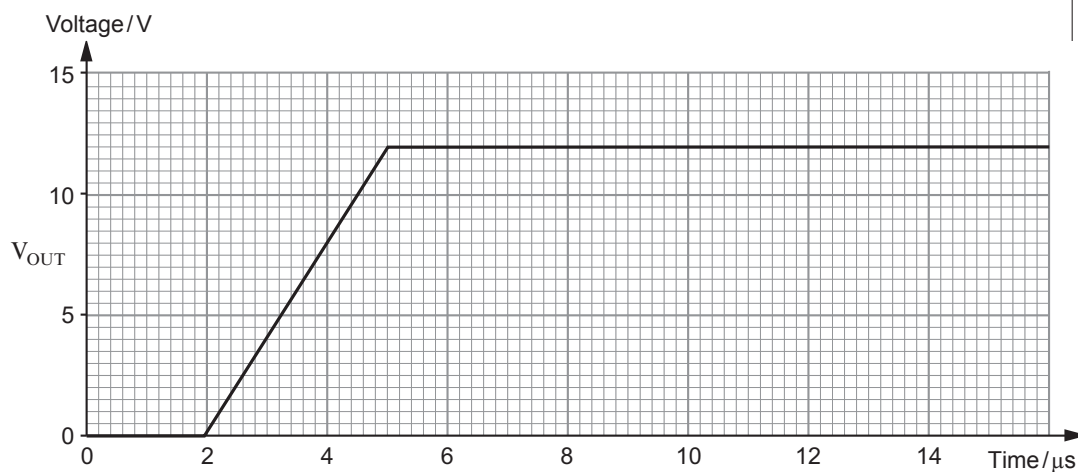
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- (c) (i) Another amplifier has a voltage gain of 50 with a bandwidth of 22 kHz. Sketch the frequency response of this amplifier on the axes below.

[2]

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- (ii) The graph shows how the output voltage of the amplifier responds to a **large** step input voltage.



Calculate the slew rate of this amplifier and give an appropriate unit.

[2]

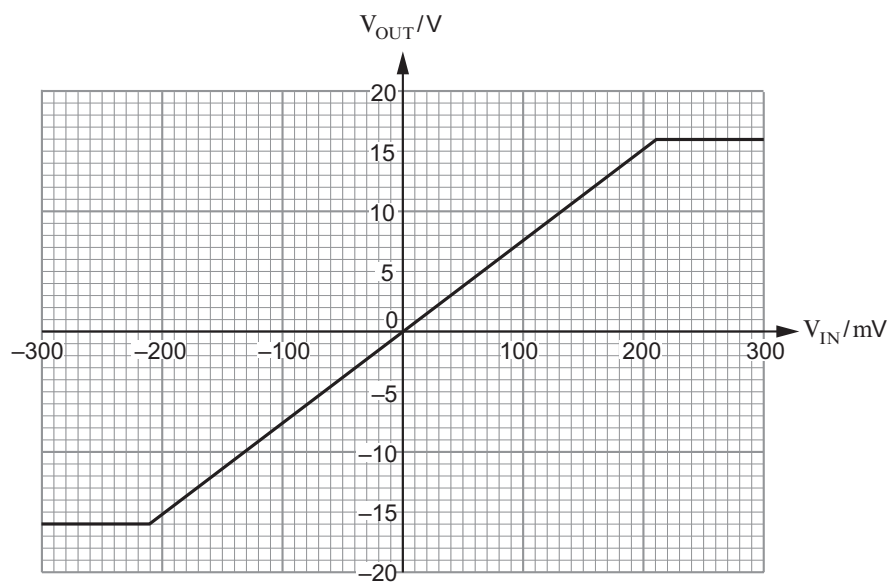
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Question 6

16

7. The graph shows the characteristic of a non-inverting op-amp voltage amplifier.

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- (a) Use the graph to determine:

(i) the saturation voltage;

[1]

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.....

(ii) the voltage gain of this amplifier.

[1]

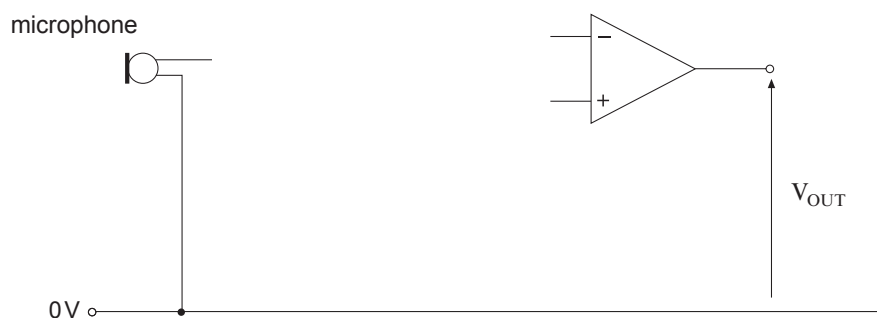
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The amplifier is modified to have a voltage gain of 80 and it is used to amplify the signal from a microphone.

- (b) (i) Complete the circuit diagram for this amplifier.

[3]



- (ii) Choose suitable resistor values to give the amplifier the voltage gain of 80. Label the circuit diagram with these values.

[2]

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- (c) Calculate the maximum output voltage of the microphone that avoids clipping distortion.

[1]

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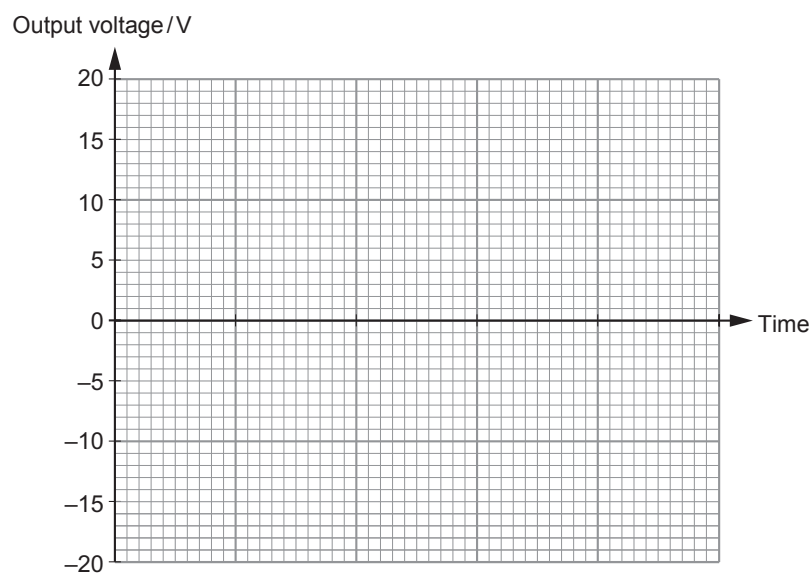
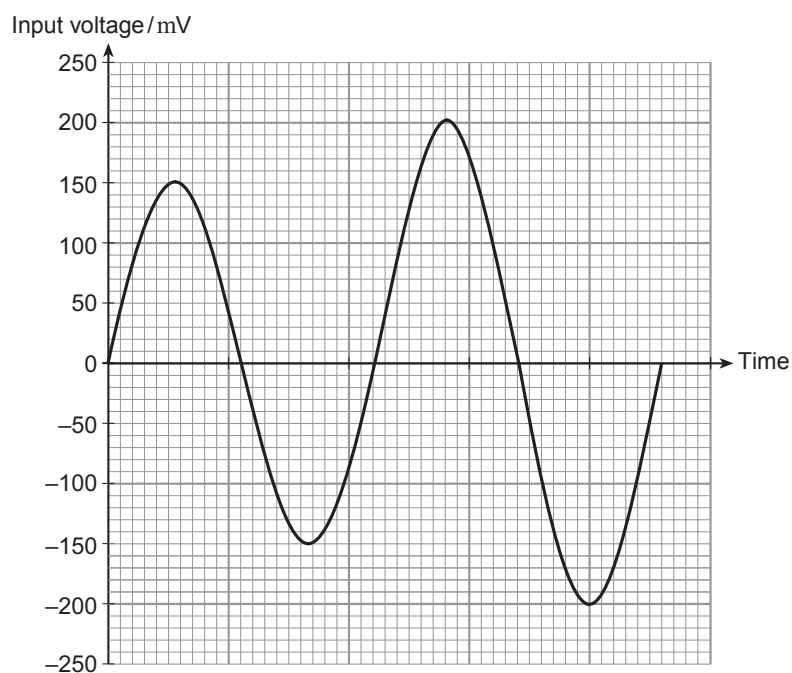
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**TURN OVER FOR THE LAST
PART OF THE QUESTION.**

The output signal of the microphone is shown below.

(d) Sketch the output produced by the amplifier.

[3]



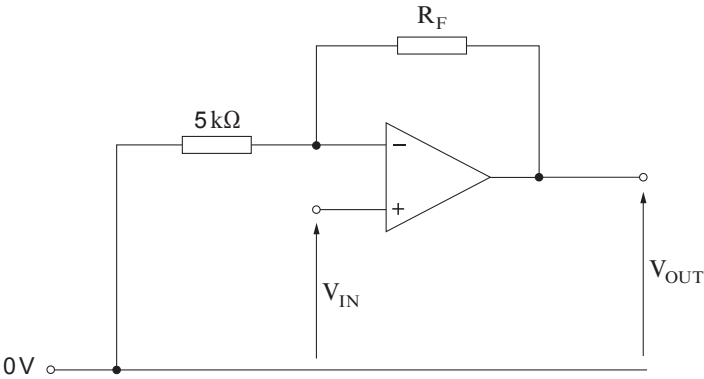
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Question 7

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8. The following diagram shows an op-amp set up as a voltage amplifier. The op-amp is powered from a $\pm 16\text{ V}$ supply. It saturates at $\pm 15\text{ V}$.



- (a) (i) Calculate the value for resistor R_F such that the voltage gain of the amplifier is 9. [1]

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- (ii) Determine the input voltage at which the amplifier just saturates. [1]

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- (b) A student varies the values of the input voltage V_{IN} from -3 V to $+3\text{ V}$.

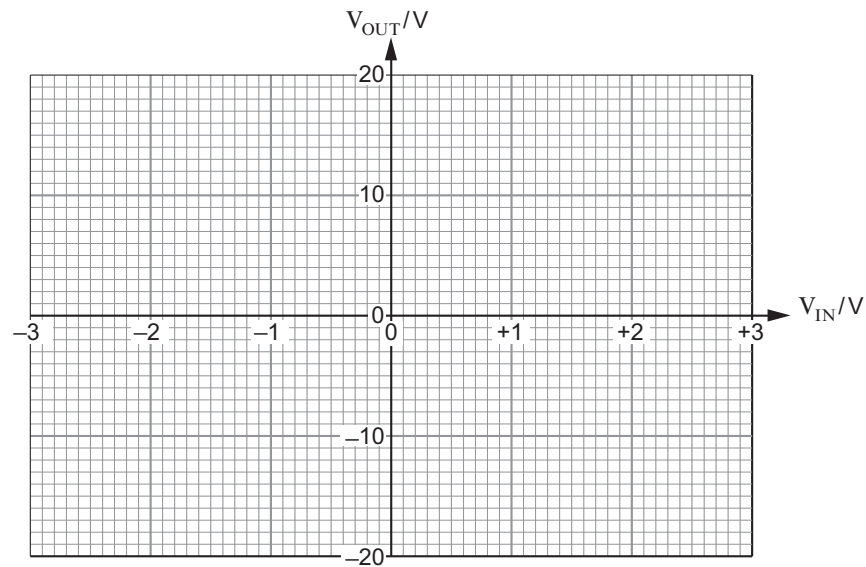
V_{IN}/V	V_{OUT}/V
-3	
-2	
-1	
+1	
+2	
+3	

- (i) Use the information in part (a) to complete the V_{OUT} column of the table. [1]

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- (ii) Draw the graph of V_{OUT} (y -axis) against V_{IN} (x -axis).

[3]

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- (c) The student replaced the $5\text{ k}\Omega$ resistor by a $4\text{ k}\Omega$ resistor.
What effect does this have on:

- (i) the input voltage at which the amplifier just saturates?

[1]

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- (ii) the gain-bandwidth product of the amplifier?

[1]

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Question 8

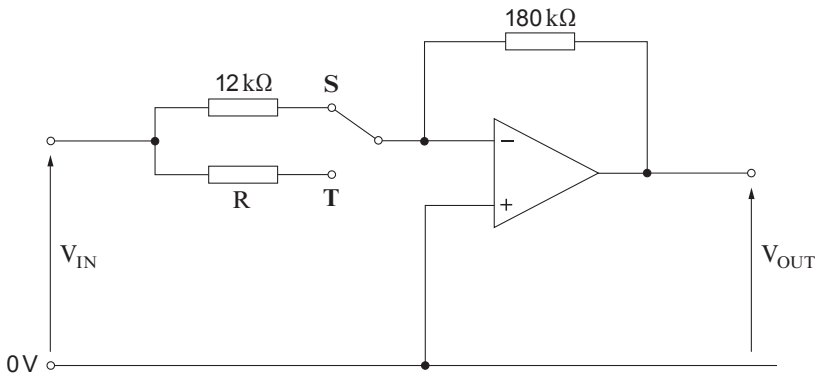
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9. An extract from the data sheet of an op-amp is shown in the following table.

Parameter	Value
Input impedance	10 MΩ
Output impedance	100 Ω
Open loop gain	10 ⁵
Gain bandwidth product	3 MHz
Slew rate	5 Vμs ⁻¹

The circuit diagram below shows an op-amp set up as a voltage amplifier. The switch allows the user to change the gain of the amplifier.



The op-amp is powered from a $\pm 15\text{ V}$ supply and saturation occurs at $\pm 14\text{ V}$. An input voltage of 0.9 V is applied to V_{IN} .

(a) The switch is initially connected to position S.

(i) Determine the input impedance of the amplifier. [1]

(ii) Calculate the voltage gain of the amplifier. [1]

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- (iii) Calculate the output voltage when $V_{IN} = 0.9V$.

[2]

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- (iv) Calculate the bandwidth of the amplifier.

[2]

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- (b) The switch is moved to position T. This doubles the gain of the amplifier.
Calculate:

- (i) the value of resistor R;

[1]

.....

.....

- (ii) the output voltage for $V_{IN} = 0.9V$.

[1]

.....

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- (c) State what change, **if any**, has occurred to the bandwidth after the switch is moved from position S to T.

[1]

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- (d) In response to a large step input, the output of the op-amp changes from $-14V$ to $+14V$.
Calculate the time taken for this change in output voltage to occur.

[2]

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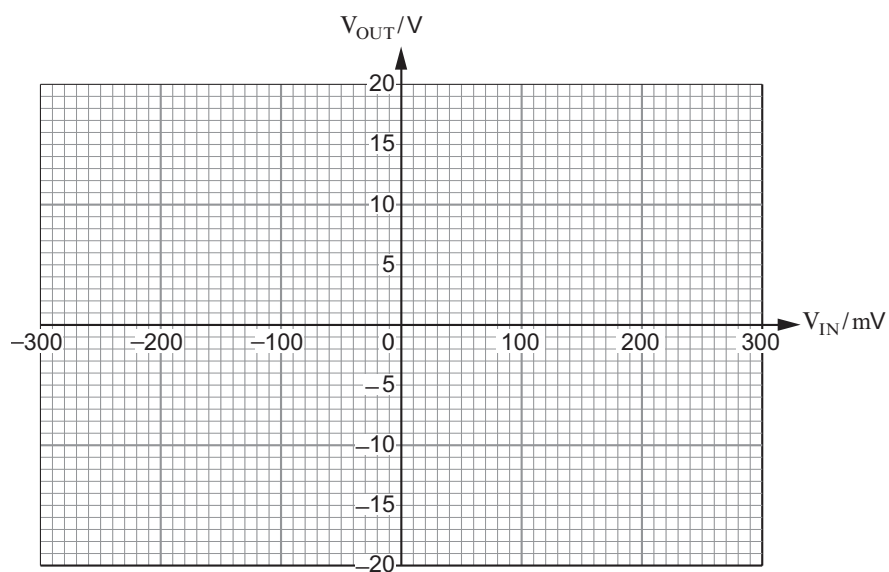
Question 9

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9. A voltage amplifier is designed to have a voltage gain of -75 . It uses an op-amp of gain-bandwidth product 3.6 MHz and it saturates at $\pm 18\text{ V}$.

- (a) Draw the voltage transfer characteristic of this voltage amplifier for input voltages between $\pm 300\text{ mV}$. [3]



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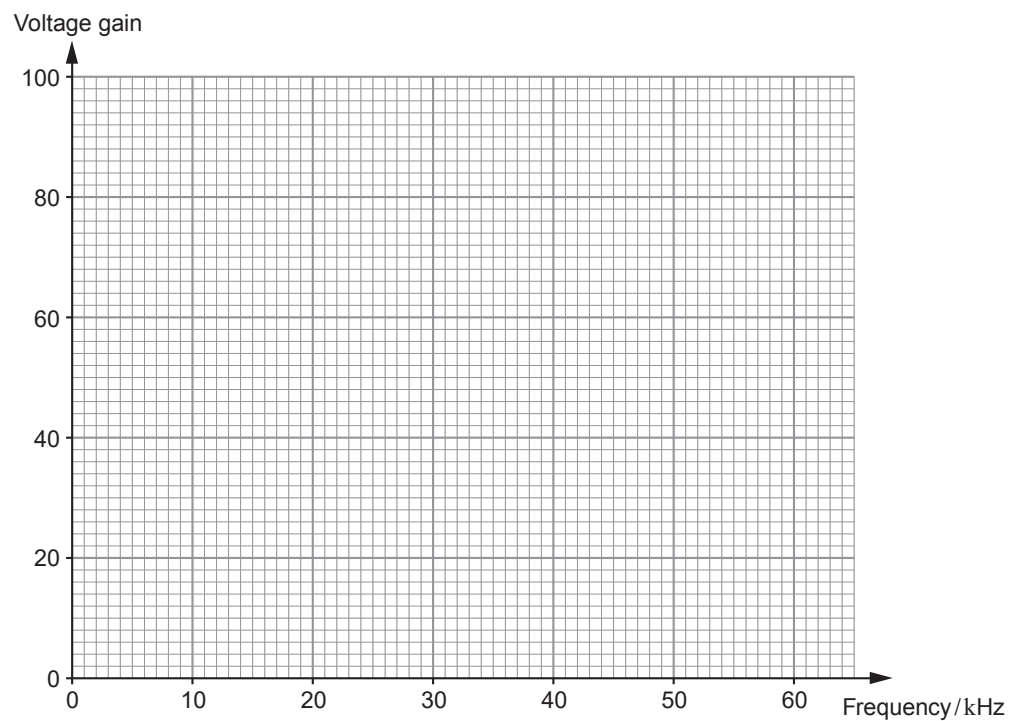
- (b) (i) Calculate the bandwidth for a voltage gain of -75 .

[1]

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- (ii) Use the axes provided to draw the frequency response of this amplifier.

[2]



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- (c) This voltage amplifier can be constructed using an operational amplifier and other components.

- (i) Complete the circuit diagram for this voltage amplifier.

[3]

V_{IN} ○ ————— ○ V_{OUT}

0V ○ —————

- (ii) Label the circuit diagram with suitable resistor values to give the amplifier a voltage gain of -75 . (Resistor values must be $1\text{ k}\Omega$ or greater.)

[2]

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