Candidate Name	Centre Number	Candidate Number

GCE A level

1145/01

ELECTRONICS

ET5

P.M. FRIDAY, 10 June 2011

1½ hours

For Examiner's use only		
Question	**Maximum Mark**	**Mark Awarded**
1.	**4**	
2.	**8**	
3.	**9**	
4.	**8**	
5.	**7**	
6.	**8**	
7.	**10**	
8.	**16**	
Total	**70**	

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ADDITIONAL MATERIALS

In addition to this examination paper, you will need a calculator.

INSTRUCTIONS TO CANDIDATES

Use black ink or black ball-point pen.

Write your name, centre number and candidate number in the spaces at the top of this page.

Answer **all** questions.

Write your answers in the spaces provided in this booklet.

INFORMATION FOR CANDIDATES

The total number of marks available for this paper is 70.

The number of marks is given in brackets at the end of each question or part-question.

You are reminded of the necessity for good English and orderly presentation in your answers.

You are reminded to show all working. Credit is given for correct working even when the final answer given is incorrect.

INFORMATION FOR THE USE OF CANDIDATES

Preferred Values for resistors

The figures shown below and their decade multiples and sub-multiples are the E24 series of preferred values.

10, 11, 12, 13, 15, 16, 18, 20, 22, 24, 27, 30, 33, 36, 39, 43, 47, 51, 56, 62, 68, 75, 82, 91.

Standard Multipliers:

Prefix	Multiplier
T	$\times 10^{12}$
G	$\times 10^{9}$
M	$\times 10^{6}$
k	$\times 10^{3}$

Prefix	Multiplier
m	$\times 10^{-3}$
µ	$\times 10^{-6}$
n	$\times 10^{-9}$
p	$\times 10^{-12}$

Alternating Voltages $V_o = V_{rms}\sqrt{2}$

Silicon Diode $V_F \approx 0{\cdot}7\text{V}$

Operational amplifier

$G = -\frac{R_F}{R_{IN}}$ Inverting amplifier

$G = 1 + \frac{R_F}{R_1}$ Non-inverting amplifier

$V_{OUT} = V_{DIFF}\left(\frac{R_F}{R_1}\right)$ Difference amplifier

$V_{OUT} = -R_F\left(\frac{V_1}{R_1} + \frac{V_2}{R_2} + \frac{V_3}{R_3}\right)$ Summing amplifier

$V_L \approx V_Z\left(1 + \frac{R_F}{R_1}\right)$ Stabilised power supply

Emitter follower $V_{OUT} = V_{IN} - 0.7\text{ V}$

Filters

$f_b = \frac{1}{2\pi RC}$ Break frequency for high pass and low pass filters

$X_C = \frac{1}{2\pi fC}$ Capacitive reactance

Thyristor phase control

$\phi = \tan^{-1}\frac{R}{X_C}$

$\tan\phi = \frac{R}{X_C}$

Modulation $\text{resolution} = \frac{\text{i/p voltage range}}{2^n}$ ADC

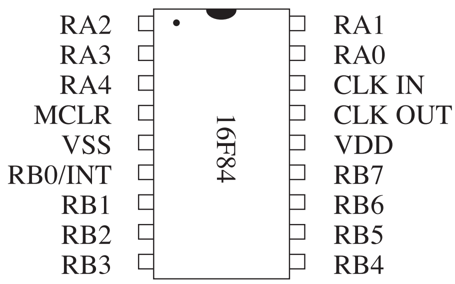
Power amplifier $P_{max} = \frac{V_S^2}{8R_L}$ where V_S is the rail-to-rail voltage

PIC Information

The PIC programs include ‘equate’ statements that define the following labels:

Label	Description
PORTA	input / output port A
PORTB	input / output port B
TRISA	the control register for port A
TRISB	the control register for port B
STATUS	the status register
INTCON	the interrupt control register
W	the working register (= h ‘0’)
F	the file register (= h ‘1’)
RP0	the register page selection bit 0
Z	the zero flag status bit
GIE	the global interrupt controller bit
INTE	the external interrupt enable bit

Pin out for 16F84 PIC IC:



List of commands:

Mnemonic	Operands	Description
bcf	f, b	Clear bit b of file f
bsf	f, b	Set bit b of file f
btfss	f, b	Test bit b of file f, skip next instruction if bit is set
call	k	Call subroutine k
clrf	f	Clear file f
goto	k	Branch to label k
movf	f, d	Move file f (to itself if d = 1, or to working register if d = 0)
movlw	k	Move literal k to working register
movwf	f	Move working register to file f
retfie		Return from interrupt service routine and set global interrupt enable bit GIE

Comparison of TASM and MPASM languages:

Version		TASM	MPASM
Number system notation	Decimal	153	d‘153’
	Hex	$2B	h‘2B’ or 0x2B
	Binary	%10010110	b‘10010110’
Opcode Notation		.equ	equ
		.org	org
		.end	end
		label:	label

Structure of the INTCON register

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
GIE	EEIE	TOIE	INTE	RBIE	TOIF	INTF	RBIF

Structure of the STATUS register

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
IRP	RP1	RP0	TO	PD	Z	DC	C

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010003

Turn over.

Examiner only

1. *(a)* Ripple counters can produce false outputs when counting a stream of high speed pulses.
What feature of synchronous counters allows them to overcome this limitation? [1]

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(b) A synchronous counter is used to count up in binary, using only even numbers from 000 to 110 and then repeat the sequence.

This sequence is shown in the following table:

Step	**Output C (msb)**	**Output B**	**Output A (lsb)**
S_0	0	0	0
S_1	0	1	0
S_2	1	0	0
S_3	1	1	0

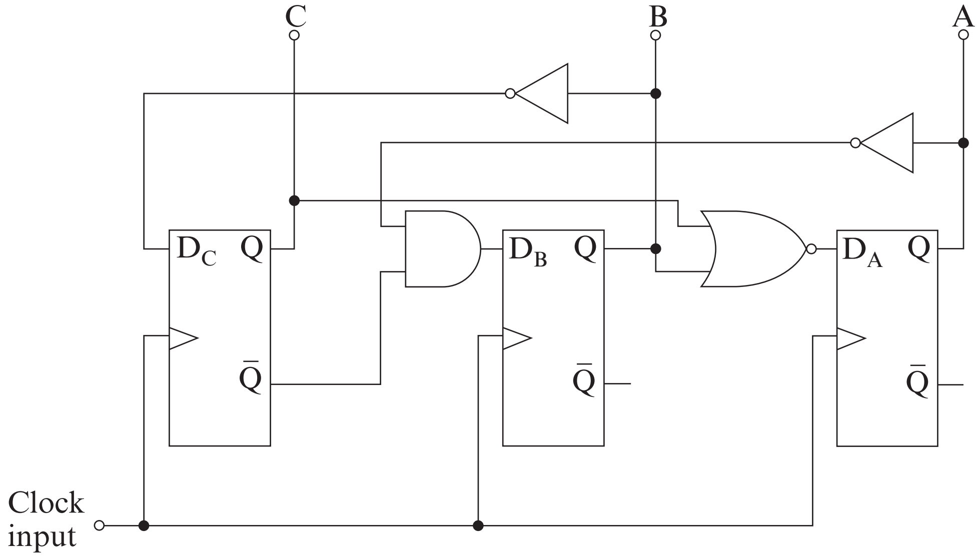
(i) The system uses a 3 bit synchronous counter. How many unused states are there? [1]

....

(ii) Draw the state diagram for this system to show:
- the main sequence;
- the unused states connected so that there are no stuck states. [2]

Examiner only

2. Here is a sequence generator.



(a) (i) Complete the Boolean expressions for the inputs D_C, D_B and D_A in terms of the outputs C, B and A. [3]

D_C = ...

D_B = ...

D_A = ...

(ii) The system uses more logic gates than it needs. Explain how the system can be re-arranged to produce the same Boolean expressions using fewer logic gates. [1]

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(b) A **different** sequence generator uses the following Boolean expressions to generate the output sequence:

$$D_B = B \oplus A$$

$$D_A = B + \overline{A}$$

(i) Use the Boolean expressions to complete the table. [3]

Step	B	A	D_B	D_A
S_0	0	0		
S_1				
S_2				
S_3				

(ii) Identify all unused states. .... [1]

Turn over.

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3. In an aircraft, a passenger can request assistance by pressing a call switch overhead. A PIC microcontroller sends appropriate signals to the cabin crew. The captain can also use this system in an emergency, but her switch has priority, causing an interrupt which overrides any other requests.

The interrupt service routine is labelled *captain*. It warns the cabin crew by sounding a buzzer in the cabin. The buzzer pulses until one of the cabin crew presses a reset switch.

(a) The interrupt vector address is 04.

Write the instruction that must be included at that address so that the microcontroller jumps to the interrupt service routine when an interrupt occurs. [2]

04 ....

(b) The Interrupt Service Routine:
- makes use of a 0.5 second time delay subroutine, called 'half', which is already written;
- controls a buzzer attached to bit 1 of PORTB;
- monitors the reset switch attached to PORTA bit 0.

(i) Complete the code for the interrupt service routine.
Some comments have been included to help you.
You should make use of commands only from the following list. You will not need to use all of these commands.

bcf bsf btfss call clrf goto movf movlw movwf retfie [5]

```
captain   movwf     Wtemp

loop      bsf       ..........   ;switch on buzzer

          call      ..........   ;wait half a second

          bcf       ..........   ;switch off buzzer

          call      ..........   ;wait half a second

          ..........  ..........   ;has the reset switch been pressed?

          ..........  ..........   ;if not, jump back and switch on the buzzer again

          ..........  ..........

          ..........
```

(ii) What is the purpose of the 'movwf' instruction that follows the label *captain*?
Explain **what** it does, and **why** this is necessary. [2]

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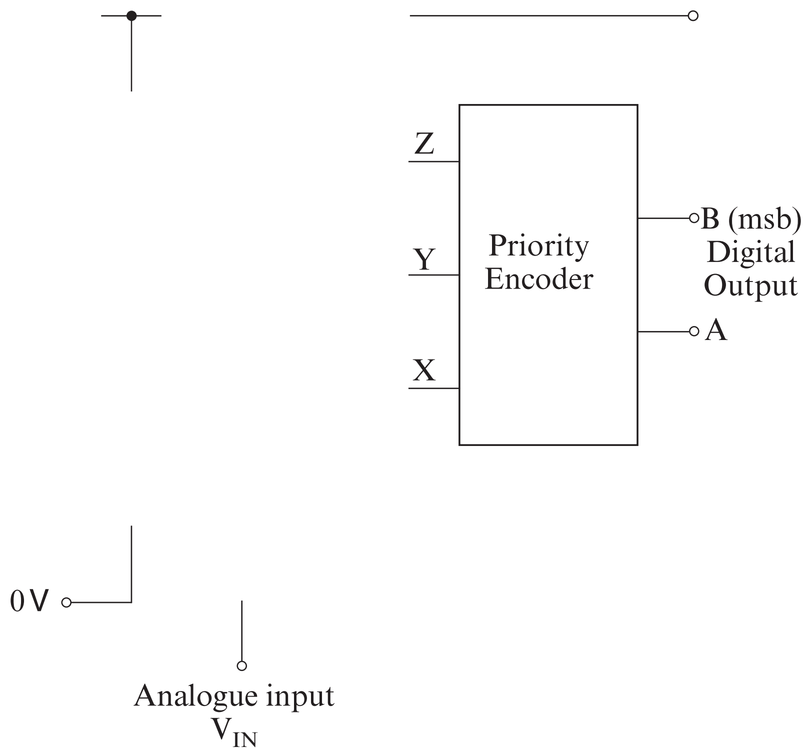
Examiner only

4. A 2-bit Analogue-to-Digital (ADC) flash converter contains the following

- an external 0.8 V reference voltage
- a chain of 47 kΩ resistors to create reference voltages for the inverting inputs of the comparators.
- a priority encoder
- an overflow output indicator

(a) Complete **and label** the circuit diagram for this ADC. [4]



Examiner only

(b) The table specifies the performance of the ADC.

Input voltage V_{IN}	Signal at Z	Signal at Y	Signal at X	Output B	Output A
$0\,V \leqslant V_{IN} < 0.2\,V$	0	0	0	0	0
$0.2\,V \leqslant V_{IN} < 0.4\,V$	0	0	1	0	1
$0.4\,V \leqslant V_{IN} < 0.6\,V$	0	1	1	1	0
$0.6\,V \leqslant V_{IN} < 0.8\,V$	1	1	1	1	1

Design the priority encoder needed to satisfy this specification by giving the Boolean expressions that link its outputs B and A to its input signals X, Y and Z. [There is no need to simplify the expressions.] [2]

....

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B = ...

....

....

A = ...

(c) Describe in detail the modifications needed to improve the resolution of this ADC to 0.1 V, for the same input voltage range. [2]

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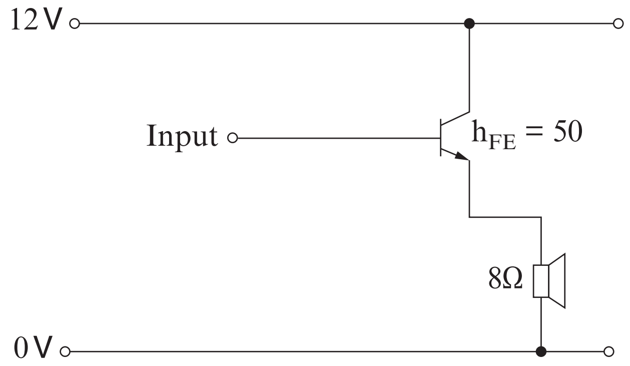
Turn over.

Examiner only

5. This question deals with two uses for emitter followers.

(a) An emitter follower is used to interface a loudspeaker to the rest of an audio system. The circuit diagram is shown below:



(i) The input voltage = 2.3V. Calculate the voltage across the loudspeaker. [1]

....

(ii) Estimate the input impedance of this arrangement. [1]

....

(iii) An AC signal, ranging from –2.3V to +2.3V is now applied to the input. What modification must be made to the circuit to prevent distortion? [1]

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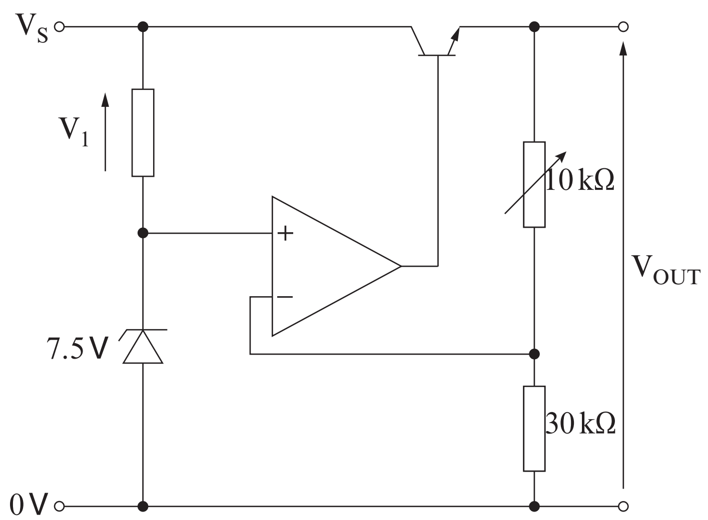
Examiner only

(b) The circuit diagram shows a voltage regulator which incorporates an emitter follower.



Initially the supply voltage, V_s is 12 V.

(i) Calculate voltage V_1. [1]

....

(ii) The output voltage, V_{OUT}, can be changed by adjusting the 10 kΩ variable resistor.
Calculate the maximum and minimum possible values of V_{OUT} with this arrangement. [2]

....

....

Maximum value = ... Minimum value = ...

(iii) The supply voltage, V_s, increases to 13 V.
Explain why the output voltage range remains unchanged. [1]

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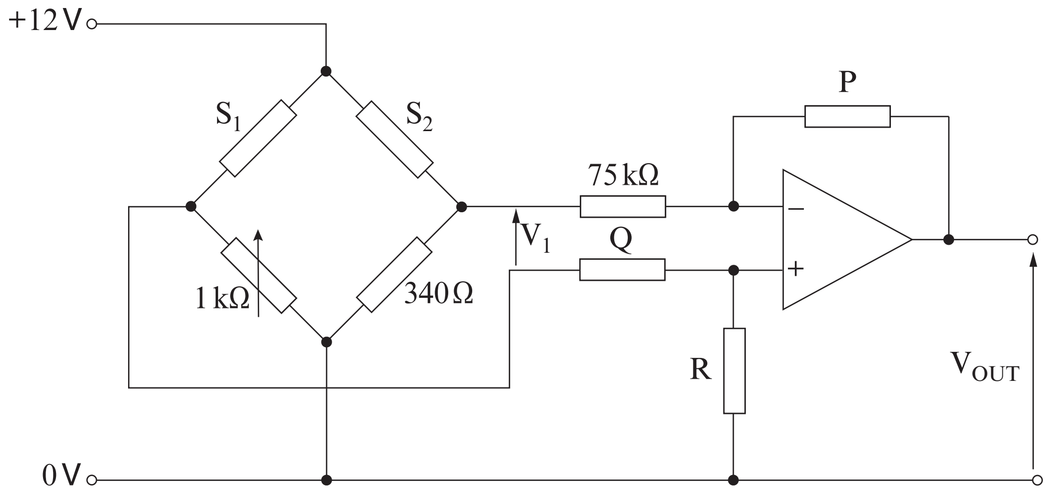
Turn over.

Examiner only

6. A strain monitoring system incorporates two identical strain gauges S_1 and S_2 and a difference amplifier. The circuit diagram is shown below.



(a) S_2 is included as a dummy strain gauge. What is its purpose in this circuit? [1]

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(b) Calculate the voltage V_1 when:

- S_1 has a resistance of 318.06 Ω,
- S_2 has a resistance of exactly 340 Ω,
- the variable resistor is set to a resistance of exactly 340 Ω.

Give your answer correct to two decimal places. [3]

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(c) The difference amplifier has a voltage gain of 50. Choose suitable values for the resistance of P, Q and R to give this gain. [3]

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P = ... Q = ... R = ...

(d) Calculate the output voltage V_{OUT} of the system under these conditions. [1]

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Examiner only

7. *(a)* State **two** conditions necessary to make a thyristor conduct. [2]

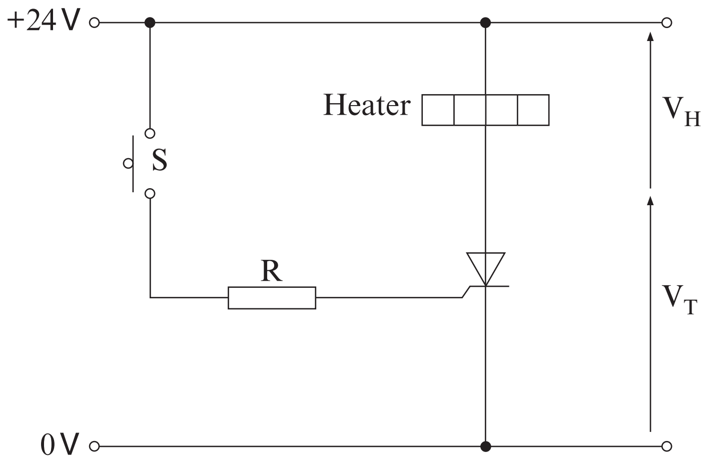
First condition ....

....

Second condition ....

....

(b) The diagram shows part of a circuit in which a thyristor is used to control a heater.



(i) Complete the table by adding the values of V_T and V_H when switch S_1 is closed and then re-opened. The thyristor is initially switched **off**. [3]

Switch S_1	Voltage V_T across thyristor	Voltage V_H across heater
Initially off		
Momentarily on		
Switched off		

Examiner only

(ii) The next table contains data for a thyristor:

Property	Typical value
Max. forward current	10 A
Holding current	100 mA
Minimum gate current	60 mA
Gate voltage	2.0 V
Peak reverse voltage	1000 V

Select appropriate data from this table to calculate the maximum ideal value for resistor R. [2]

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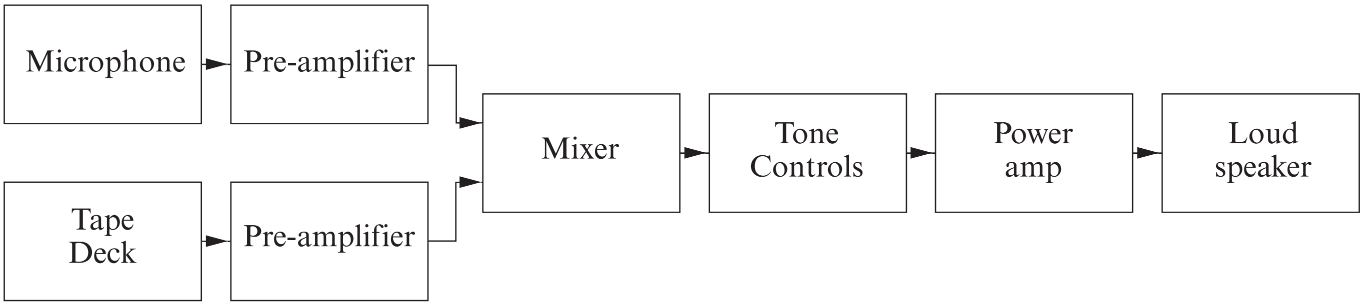
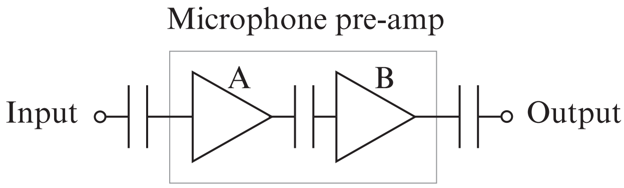
(iii) **Complete the circuit diagram** by adding a switch S_2 and other components needed to turn off the thyristor using *capacitor commutation.* [3]

Examiner only

8. Here is the block diagram for a public address system.



(a) The microphone pre-amplifier is a 2-stage amplifier with an overall gain of 2500.



(i) The pre-amplifier uses three decoupling capacitors.
What is the purpose of these capacitors? [1]

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(ii) The table gives some data on the dual op-amp used for amplifiers A and B.

Parameter	**Typical Value**
Open-loop voltage gain	5×10^4
Input resistance	$6 \times 10^6\,\Omega$
Gain bandwidth product	1.6×10^6 Hz
Slew-rate	$0.3\,\text{V}\,\mu\text{s}^{-1}$
Common mode rejection ratio	100 dB

I. In order to maximise the bandwidth of this pre-amp, what is the gain of:

amplifier A, ...

amplifier B? .... [2]

II. What is the resulting bandwidth of the pre-amplifier? [1]

....

....

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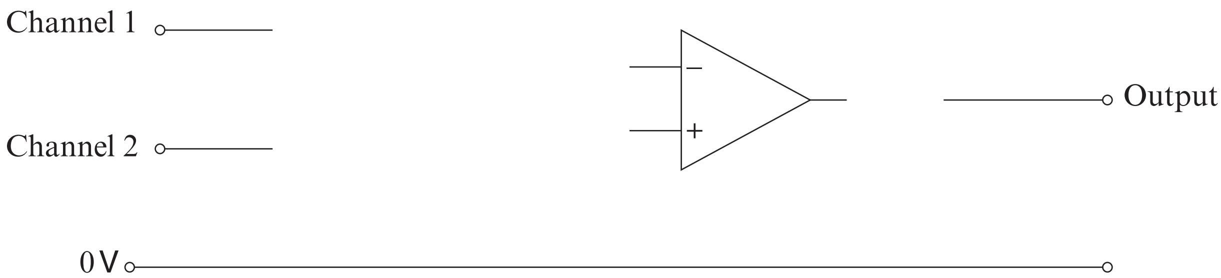
(b) Part of the specification for the mixer is given below. It must be possible to 'fade' in each input signal.

Description	Value
Number of input channels	2
Maximum voltage gain on input channel 1	10
Maximum voltage gain on channel 2	5
Minimum input impedance (either channel)	10 kΩ

(i) Complete the following circuit diagram for the mixer. [3]



(ii) Calculate suitable values for the **fixed** resistors used in the circuit. [3]

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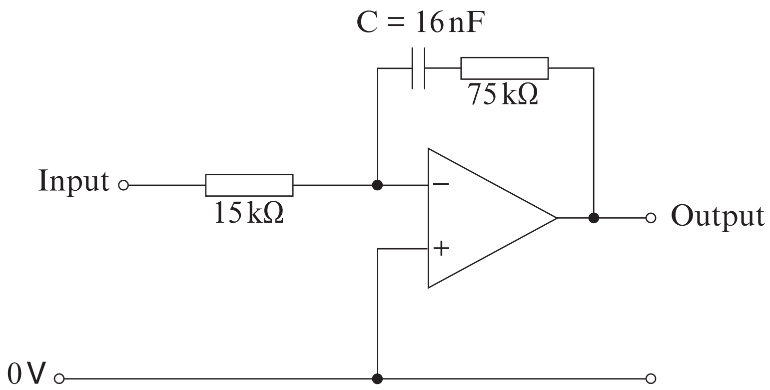
(c) The tone-control circuit contains a bass-boost filter, as shown below.



(i) Calculate the break frequency of this filter. [2]

....

....

....

(ii) Calculate the voltage gain of the filter at frequencies well above the break frequency. [1]

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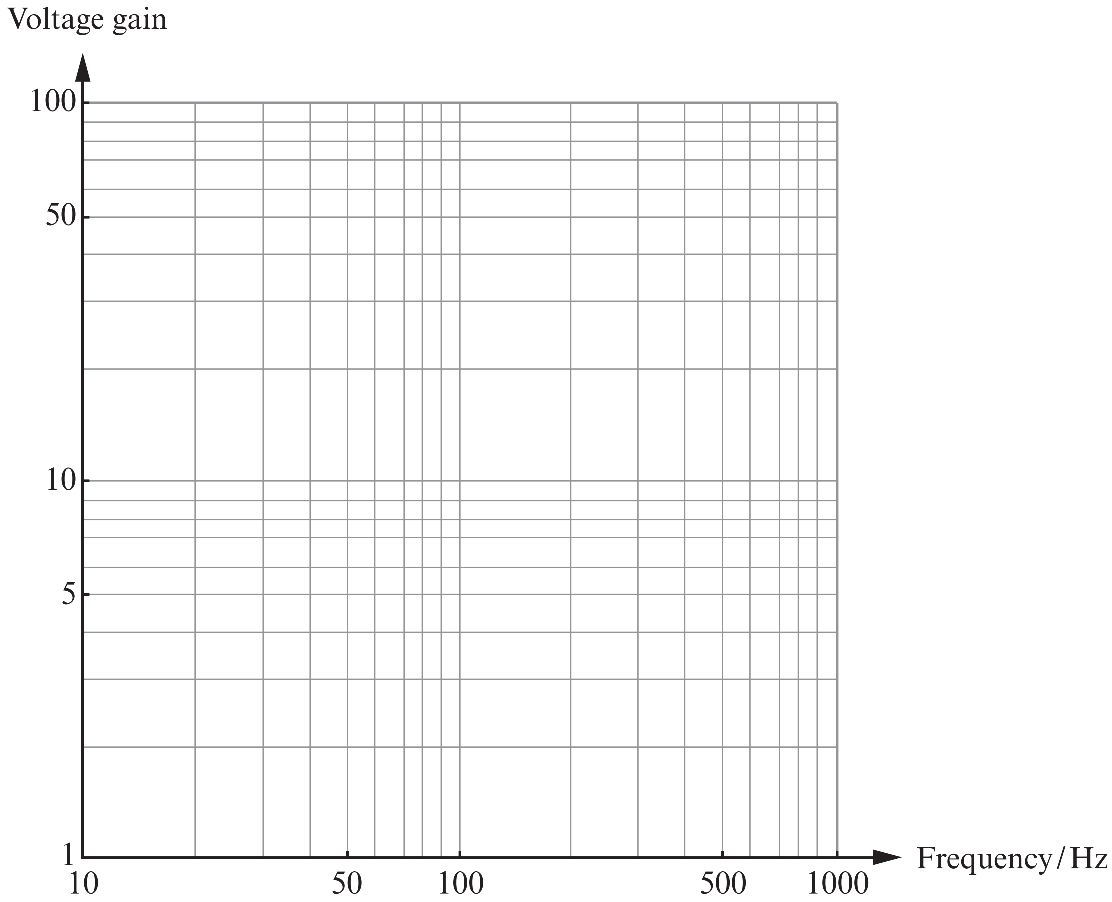
(iii) Use the axes provided to sketch the frequency response of this filter. [3]



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