Centre Number						Candidate Number				
Surname										
Other Names										
Candidate Signature										

For Examiner's Use	
Examiner's Initials	
Question	Mark
1	
2	
3	
4	
5	
6	
TOTAL	

General Certificate of Education
Advanced Subsidiary Examination
June 2013

Electronics ELEC2

Unit 2 Further Electronics

Tuesday 21 May 2013 1.30 pm to 2.30 pm

For this paper you must have:
- a pencil and ruler
- a calculator
- a Data sheet (enclosed).

Time allowed
- 1 hour

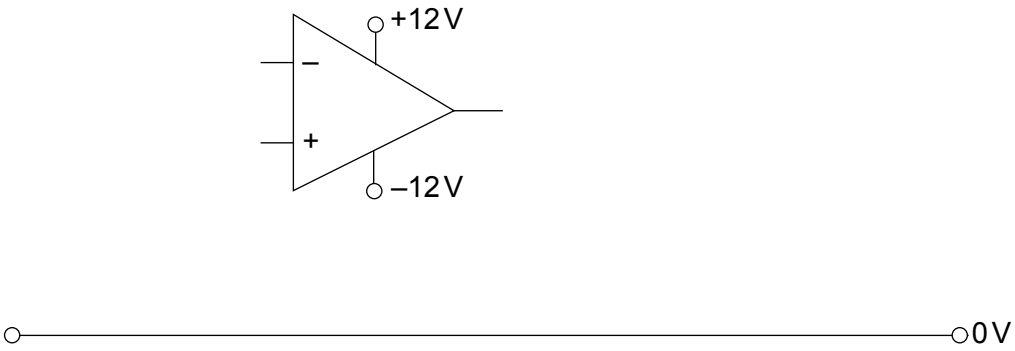
Instructions
- Use black ink or black ball-point pen.
- Fill in the boxes at the top of this page.
- Answer **all** questions.
- You must answer the questions in the spaces provided. Do not write outside the box around each page or on blank pages.
- Do all rough work in this book. Cross through any work you do not want to be marked.

Information
- The marks for questions are shown in brackets.
- The maximum mark for this paper is 67.

Answer **all** questions in the spaces provided.

1 A circuit is required to amplify the output voltage from a microphone by a factor of 100. The input resistance of the amplifier must be 4.7 kΩ to match the internal resistance of the microphone.

1 (a) In the space below, complete the circuit diagram of a suitable op-amp amplifier and give suitable resistor values to match the specification. The circuit can be inverting or non-inverting.



(4 marks)

1 (b) The op-amp is powered by a ±12 V supply. Assuming an ideal op-amp is used, calculate the maximum amplitude of the input signal before the output becomes saturated.

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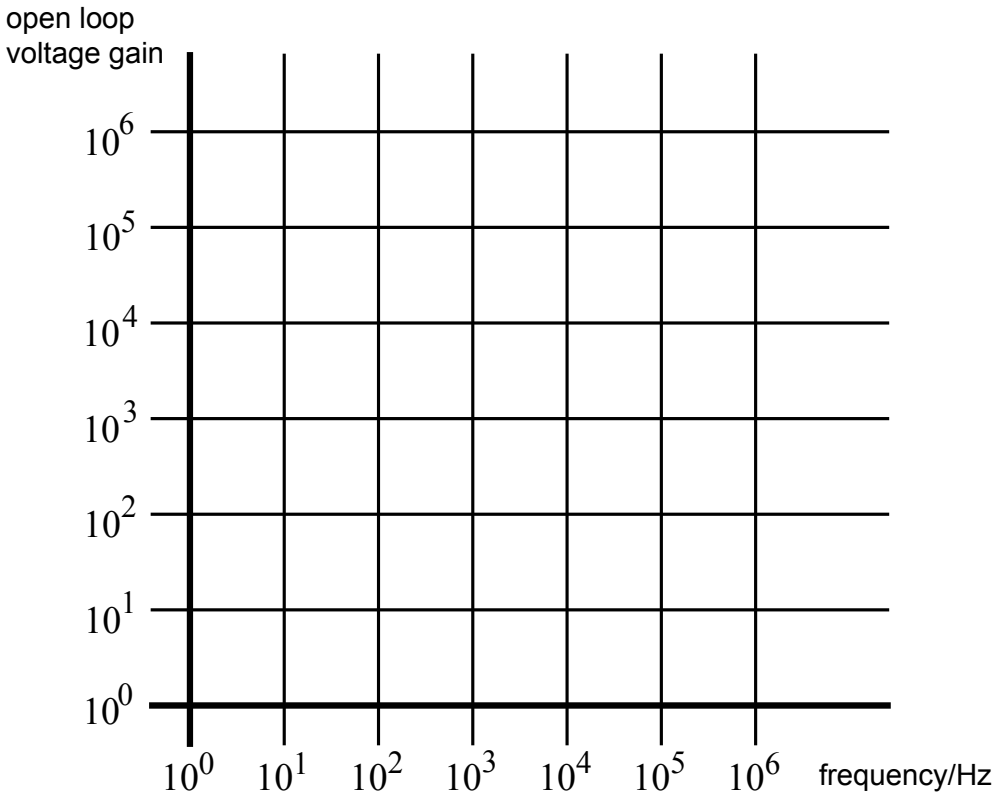
(2 marks)

1 (c) The op-amp has a gain-bandwidth product of 1 MHz. Draw on the graph below how the open loop voltage gain of the op-amp varies with frequency.



(3 marks)

1 (d) Calculate the frequency above which the voltage gain of the amplifier is less than 100.

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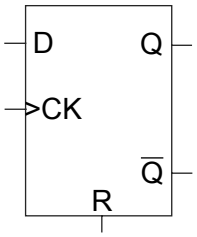
(2 marks)

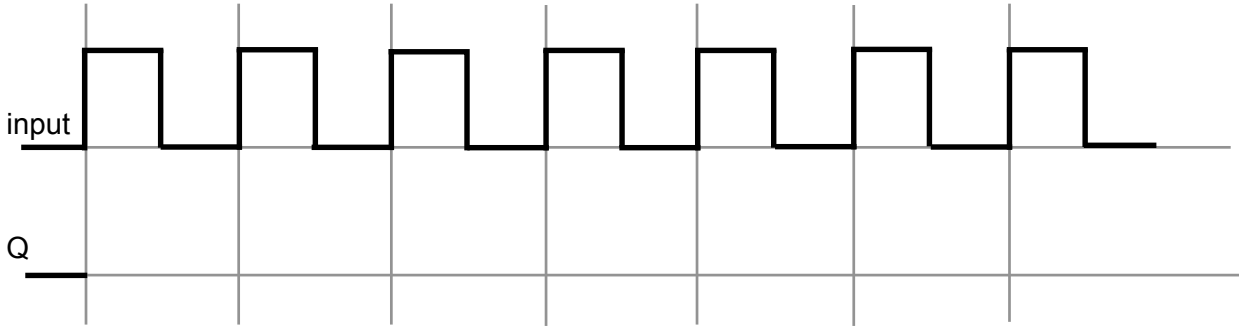
11

2 (a) (i) Complete the circuit diagram below to show how a D-type flip-flop can be connected to divide a clock frequency by 2, and label the input and output.



(3 marks)

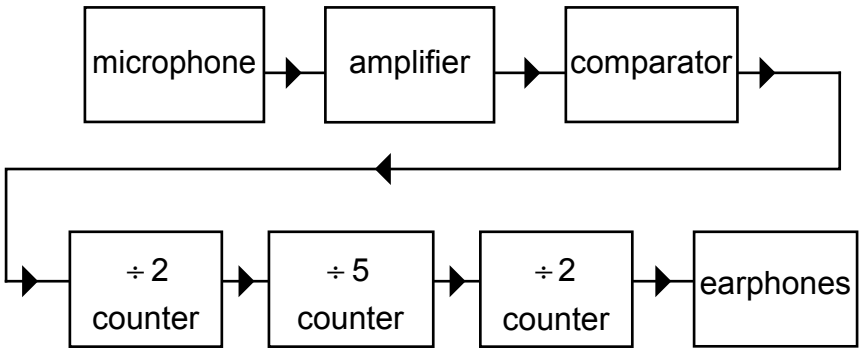
2 (a) (ii) Complete the timing diagram to show the relationship between the input signal and Q.



(2 marks)

2 (b) Bats navigate using ultrasonic waves between 30 kHz and 60 kHz.

A student designs the following system to investigate these sounds.



2 (b) (i) If the system receives ultrasonic waves at a frequency of 48 kHz, calculate the frequency of the signal at the earphones.

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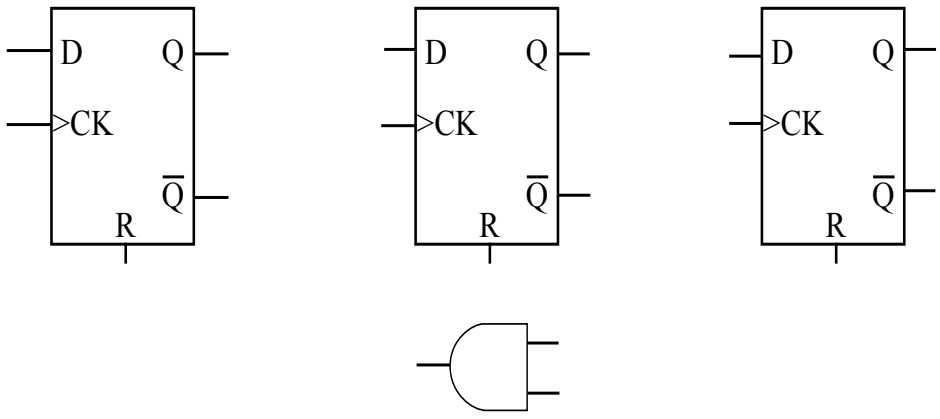
(2 marks)

2 (b) (ii) Complete the circuit diagram below for a divide by 5 counter.



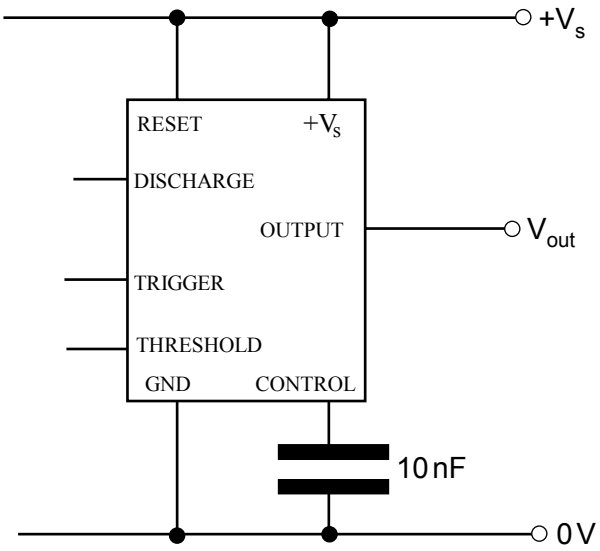
(4 marks)

11

Turn over ▸

3 A musician wants to build an electronic circuit to replace his 440 Hz mechanical tuning fork.
He decides to use a 555 timer IC astable circuit.

3 (a) Complete the circuit diagram below for a 555 astable.
Add two resistors, a capacitor and any wire links that you need.



(4 marks)

3 (b) The circuit is initially set up with R_A = 1 kΩ, R_B = 100 kΩ and C =15 nF.
Using the formula on the data sheet, show that the output frequency is about 480 Hz.

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(3 marks)

3 (c) To adjust the circuit to the correct frequency, the value of R_B is to be changed.
Calculate the new value of R_B which will give an output frequency of 440 Hz.

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(3 marks)

3 (d) This new value for R_B is not a preferred value.
How would you modify the circuit to obtain the correct frequency?

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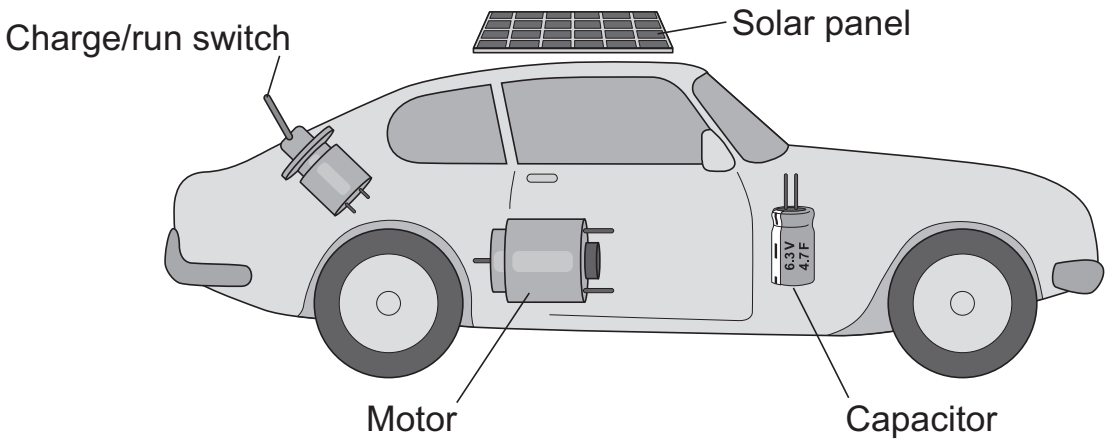
(2 marks)

12

Turn over for the next question

4 Very high value electrolytic type capacitors are now available, with values up to 150 F. A student decides to use this type of capacitor together with a solar panel, to make a solar powered toy car. The student uses a 4.7 F, 6.3 V capacitor.



4 (a) In normal room light, the solar panel can be considered to be a 6 V voltage source in series with a 6.8 Ω resistor.
Assuming that the solar panel is in normal room light and that it is connected to the uncharged 4.7 F capacitor, calculate the time taken to fully charge the capacitor.

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(3 marks)

4 (b) Using the switch, the capacitor is disconnected from the solar panel and connected to the motor. The motor can be considered as a resistor of value 5 Ω, and stops rotating when the supply voltage falls below 2.2 V.
Estimate the time for which the motor operates, assuming that the capacitor is initially charged to 6 V.

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(3 marks)

4 (c) In bright sunlight, the solar panel behaves as a 9 V voltage source in series with a 6.8 Ω resistor. To cope with the increase in voltage, the student connects two 4.7 F 6.3 V capacitors in series.

Calculate the effective capacitance of the arrangement.

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(3 marks)

4 (d) When charged to 9 V, the voltage across the capacitors is found to be different and not shared equally.

Using your knowledge of electrolytic type capacitors, suggest **two** reasons for this.

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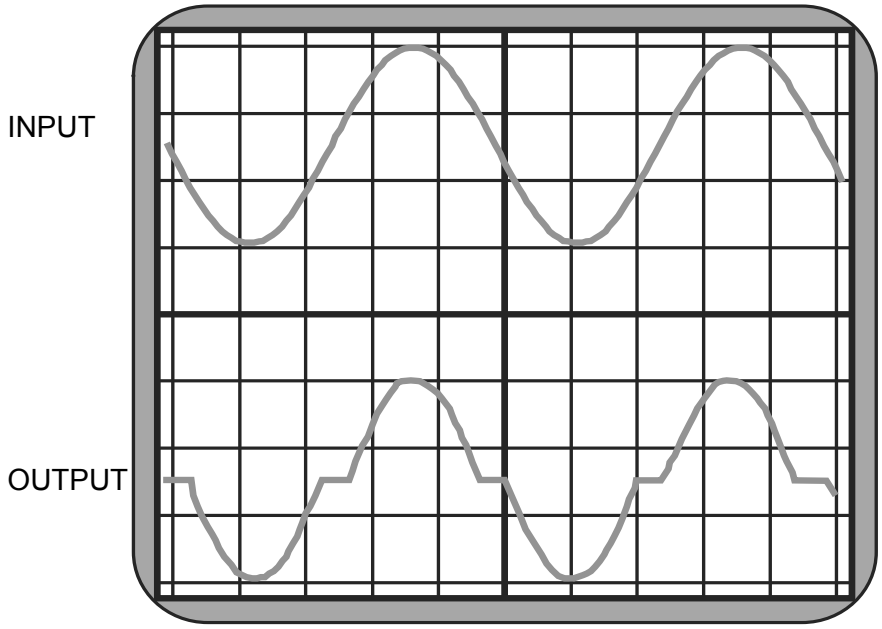
(2 marks)

11

Turn over for the next question

5 A student constructs a push-pull audio amplifier and connects it to an 8 Ω loudspeaker. A signal generator is used to provide an input signal and the input and output signals are shown on the oscilloscope trace diagram below.



5 (a) (i) If the timebase is set to 0.5 ms / div, estimate the frequency of the signal.

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(2 marks)

5 (a) (ii) If the input signal trace has a sensitivity of 0.1V/div, estimate the amplitude of the input signal.

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(2 marks)

5 (a) (iii) If the output signal has an amplitude of 7.5 V, estimate the output power of the amplifier.

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(2 marks)

5 (b) The output signal is distorted. State the name of this type of distortion.
State **two** ways in which this distortion can be reduced.

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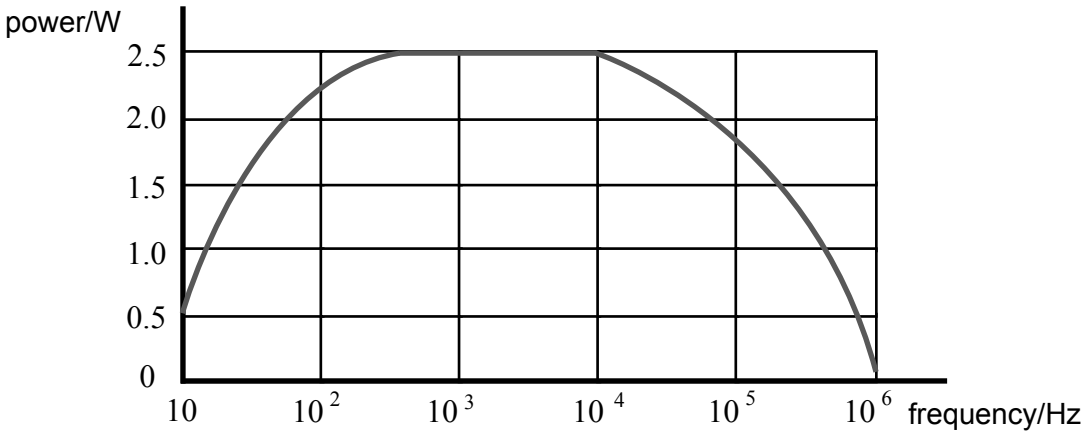
(3 marks)

5 (c) The student measures the output power of a different amplifier at a range of frequencies, while keeping the amplitude of the input signal constant.
A graph of the results is shown below.



Estimate the bandwidth of the amplifier.

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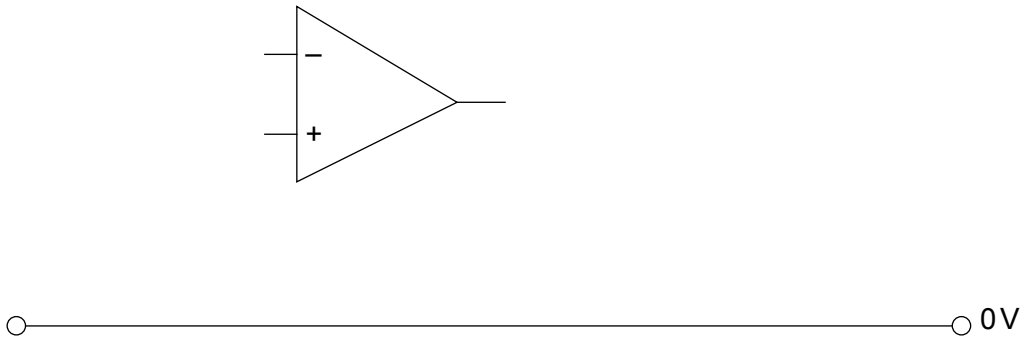
(2 marks)

11

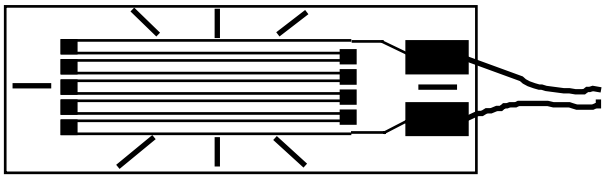
6 (a) Complete the circuit diagram below for a difference amplifier with a voltage gain of 100. Label the inputs and output.



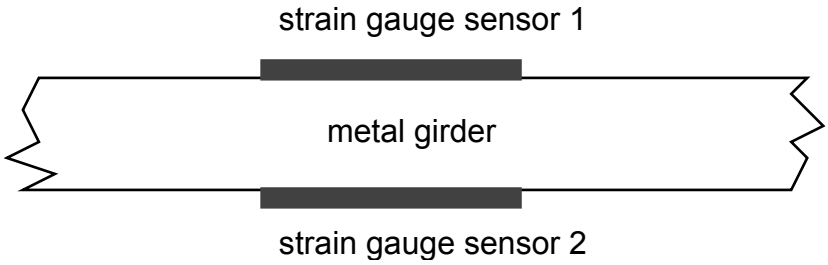
(6 marks)

6 (b) The difference amplifier is used with strain gauge sensors to measure the strain on a metal girder in a bridge.

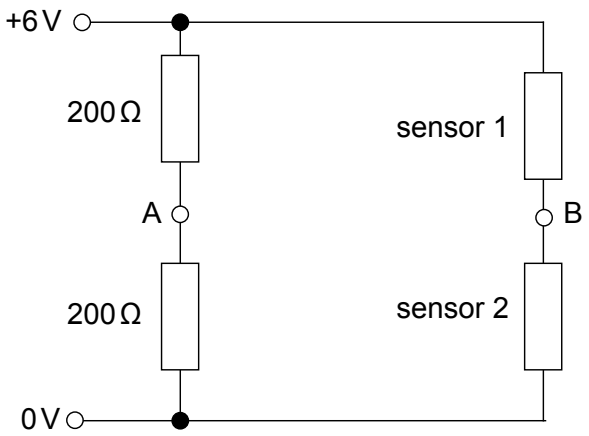
A strain gauge sensor consists of very fine wires enclosed in a plastic case, as shown below. When the sensor is stretched its resistance increases and when compressed its resistance decreases. The changes in resistance are very small.



Two strain gauge sensors are glued to the girder, one to the top and one to the bottom, as shown below.



When the girder bends, the resistance of sensor 1 decreases and the resistance of sensor 2 increases.
The sensors are connected to the circuit shown on the next page.



6 (b) (i) What is the voltage at point A?

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(1 mark)

6 (b) (ii) If sensor 1 and sensor 2 are both unstrained and each has a resistance of 200 Ω, what will be the difference in voltage between points A and B?

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(1 mark)

6 (c) The inputs to the difference amplifier in part (a) are connected to points A and B. When the metal girder bends a small amount, the resistance of sensor 1 decreases by 1% and that of sensor 2 increases by 1%.

Estimate, showing your calculation, the output voltage of the difference amplifier under these conditions.

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(3 marks)

11

END OF QUESTIONS

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