Surname		Other Names	
Centre Number			Candidate Number	
Candidate Signature			

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General Certificate of Education
June 2005
Advanced Subsidiary Examination

ASSESSMENT and QUALIFICATIONS ALLIANCE

ELECTRONICS ELE2
Unit 2 Further Electronics

Thursday 26 May 2005 Afternoon Session

In addition to this paper you will require:
- a calculator;
- a pencil and a ruler.

Time allowed: 1 hour 30 minutes

Instructions
- Use blue or black ink or ball-point pen. Use pencil for drawing.
- Fill in the boxes at the top of this page.
- Answer **all** questions in the spaces provided. All working must be shown.
- Do all rough work in this book. Cross through any work you do not want marked.
- A *Data Sheet* is provided on pages 3 and 4. Detach this perforated sheet at the start of the examination.
- Pages 13 and 14 are perforated pages. Detach these pages and use the diagram on page 14 to help you to answer Question 6.

Information
- The maximum mark for this paper is 72.
- Mark allocations are shown in brackets.
- Any correct electronics solution will gain credit.
- The paper carries 40% of the total marks for Electronics Advanced Subsidiary and 20% of the total marks for Electronics Advanced Level awards.
- You are reminded of the need for good English and clear presentation in your answers.

For Examiner's Use			
Number	Mark	Number	Mark
1			
2			
3			
4			
5			
6			
7			
Total (Column 1) →			
Total (Column 2) →			
TOTAL			
Examiner's Initials			

Data Sheet

- A perforated *Data Sheet* is provided on pages 3 and 4 of this question paper.
- This sheet may be useful for answering some of the questions in the examination.
- Detach this sheet before you begin work.

Data Sheet

Resistors

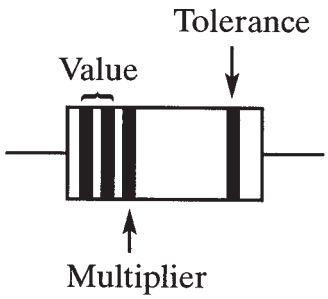
Preferred values for resistors (E24) series:
1.0, 1.1, 1.2, 1.3, 1.5, 1.6, 1.8, 2.0, 2.2, 2.4, 2.7, 3.0, 3.3, 3.6, 3.9, 4.3, 4.7, 5.1, 5.6, 6.2, 6.8, 7.5, 8.2, 9.1 ohms and multiples that are ten times greater.

Resistor Printed Code (BS 1852)

This code consists of letters and numbers:
R means $\times 1$
K means $\times 1000$ (i.e. 10^3)
M means $\times 1\,000\,000$ (i.e. 10^6)
Position of the letter gives the decimal point
Tolerances are given by the letter at the end of the code, F = ± 1%, G = ± 2%, J = ± 5%, K = ± 10%, M = ± 20%.

Resistor Colour Code

Number	Colour
0	Black
1	Brown
2	Red
3	Orange
4	Yellow
5	Green
6	Blue
7	Violet
8	Grey
9	White



Tolerance, gold = ± 5%, silver = ± 10%, no band ± 20%.

Silicon diode

$V_F = 0.7\,V$

Silicon transistor

$V_{be} \approx 0.7\,V$ in the on state
$V_{ce} \approx 0.2\,V$ when saturated

Resistance

$R_T = R_1 + R_2 + R_3$ series

$\frac{1}{R_T} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$ parallel

Capacitance

$\frac{1}{C_T} = \frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3}$ series

$C_T = C_1 + C_2 + C_3$ parallel

Time constant

$T = CR$

A.C. theory

$I_{rms} = \frac{I_o}{\sqrt{2}}$

$V_{rms} = \frac{V_o}{\sqrt{2}}$

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

$X_L = 2\pi fL$ reactance

$f = \frac{1}{T}$ frequency, period

$f_o = \frac{1}{2\pi\sqrt{LC}}$ resonant frequency

Turn over ▶

Operational amplifier

$$G_V = \frac{V_{out}}{V_{in}} \quad \text{voltage gain}$$

$$G_V = -\frac{R_f}{R_1} \quad \text{inverting}$$

$$G_V = 1 + \frac{R_f}{R_1} \quad \text{non-inverting}$$

$$V_{out} = -R_f\left(\frac{V_1}{R_1} + \frac{V_2}{R_2} + \frac{V_3}{R_3}\right) \quad \text{summing}$$

Astable and Monostable using NAND Gates

$$f \approx \frac{1}{2RC} \quad \text{astable}$$

$$T \approx RC \quad \text{monostable}$$

555 Astable and Monostable

$$T = 1.1RC \quad \text{monostable}$$

$$\left.\begin{aligned} t_H &= 0.7(R_A + R_B)C \\ t_L &= 0.7R_BC \end{aligned}\right] \quad \text{astable}$$

$$f = \frac{1.44}{(R_A + 2R_B)C} \quad \text{two resistor circuit}$$

Electromagnetic Waves

$c = 3 \times 10^8 \text{ m s}^{-1}$ speed in vacuo

List of BASIC Commands

DIM variable [(subscripts)]

DO [{**WHILE** | **UNTIL**} condition]
    [statement block]
LOOP

DO
    [statement block]
LOOP [{**WHILE** | **UNTIL**} condition]

FOR counter = start **TO** end [**STEP** increment]
    [statement block]
NEXT counter

GOSUB [label | line number]
    [statement block]
RETURN

IF condition **THEN**
    [statement block 1]
ELSE
    [statement block 2]

INKEY$

INP (port %)

INPUT [;] ["prompt" {;1, }] variable list (comma separated)

LPRINT [expression list] [{ ;1, }]

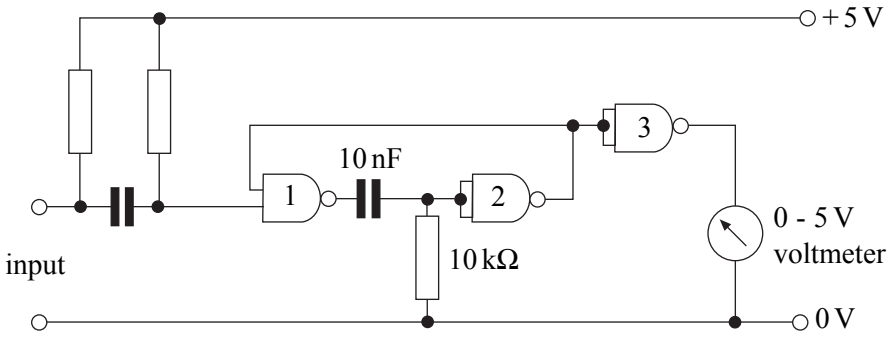
OUT port%, data%

PRINT [expression list] [{;1,}]

REM remark

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

1 Part of the circuit diagram for a simple frequency meter is shown below.



(a) How should the input signal change to trigger the monostable?

.....

(1 mark)

(b) Explain how the monostable circuit functions once it has been triggered.

.....

.....

.....

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.....

.....

(4 marks)

(c) Estimate the time period of the monostable, using the formula given on the data sheet.

.....

.....

.....

(2 marks)

(d) Estimate, showing your working, the maximum frequency that can be displayed on the frequency meter.

.....

.....

.....

(2 marks)

Turn over ▶

9

2 A trainee electronics engineer needs to amplify and low pass filter the output of a Digital to Analogue Converter (DAC). The low pass filter break point frequency is to be 2.5 kHz.

(a) Explain what is meant by:

(i) low pass filter .....

.....

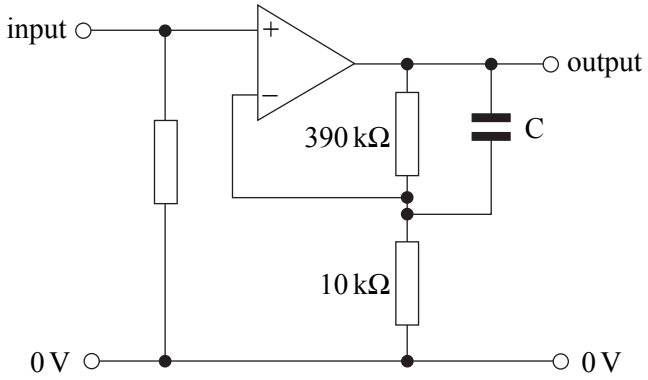
(1 mark)

(ii) break point frequency .....

.....

(1 mark)

(b) The circuit diagram used for the low pass filter is shown below.



(i) Estimate the voltage gain of the circuit well below the break point frequency, where the effect of the capacitor, C, is negligible.

.....

.....

(2 marks)

(ii) Calculate a value for C so that the circuit has a break point frequency of 2.5 kHz.

.....

.....

.....

(3 marks)

(c) The engineer uses an op-amp with a gain-bandwidth product of 10^6 Hz.
Estimate, showing your working, the maximum voltage gain that can be achieved from this op-amp at the break point frequency.

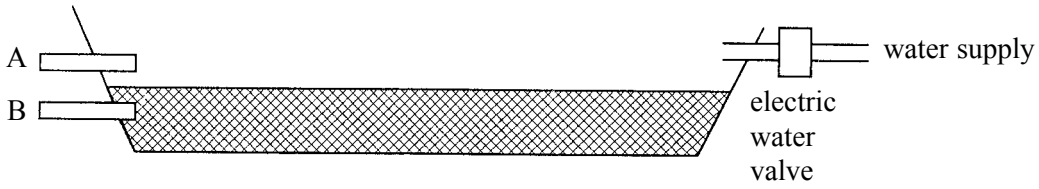
.....

.....

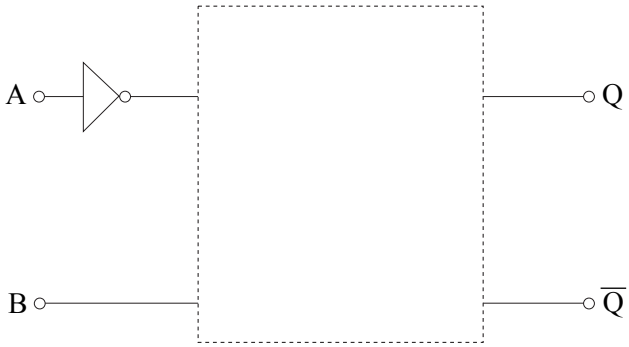
(2 marks)

9

3 The diagram below shows a drinking water trough for farm animals.



The water level is detected by sensors A and B which give a logic 0 when dry and a logic 1 when wet. They are connected to the circuit below.



(a) Complete the circuit diagram, within the dotted box, for a NAND gate bistable latch.

(2 marks)

(b) State the logic state of Q when:

(i) the water trough is empty .....

(ii) water enters the trough and sensor B becomes wet .....

(iii) water continues to enter the trough and sensor A becomes wet .....

(iv) the water level then falls and sensor A becomes dry .....

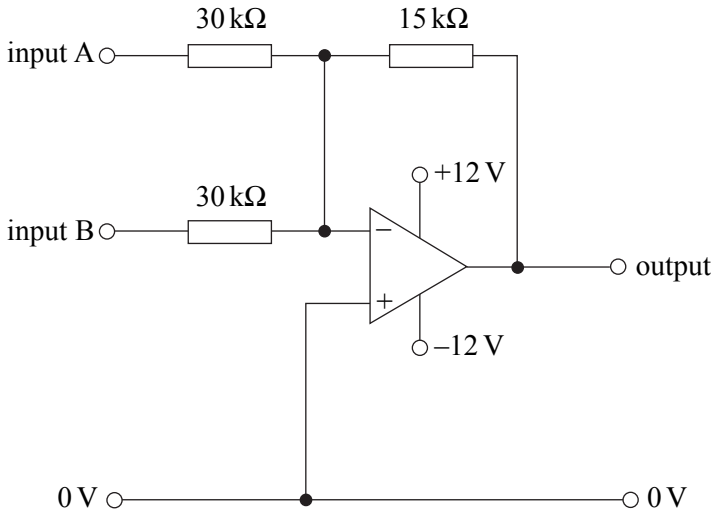
(4 marks)

(c) The whole system operates from a 12 V supply. The electric water valve contains an elecromagnet and water flows when there is more than 8 V connected across it. Draw a circuit diagram in the space below to show how an n-channel MOSFET could be used to interface the bistable latch to the water valve.

(3 marks)

9

4 The circuit diagram for a summing amplifier is shown below.



(a) Label a virtual earth point in the circuit above with the letter **P**. *(1 mark)*

(b) If input B is connected to 0 V and an audio signal of 2 V amplitude is connected to input A, calculate the amplitude of the output signal.

.....

.....

(2 marks)

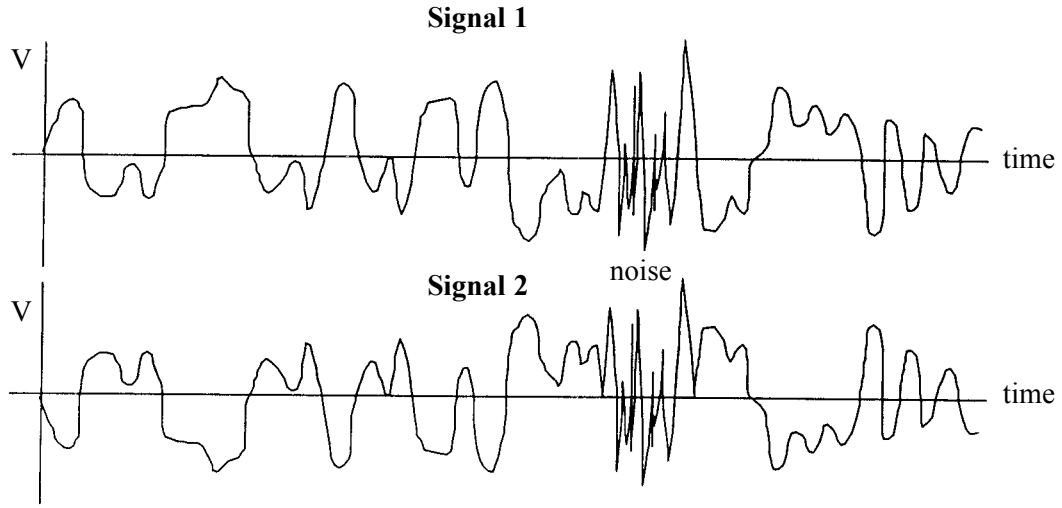
(c) With the audio signal still connected to input A, input B is disconnected from 0 V and connected to input A. What will be the amplitude of the output signal in this case?

.....

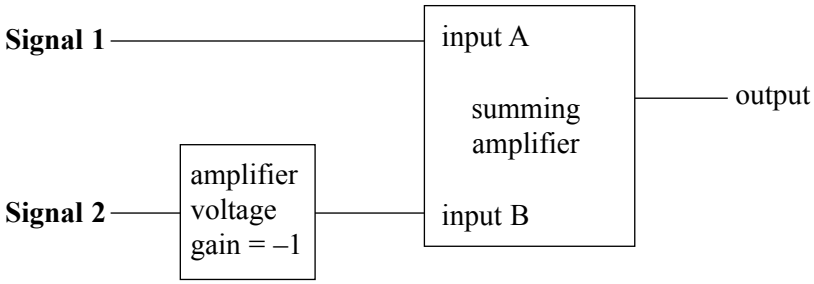
.....

(1 mark)

(d) A microphone gives two audio signal outputs with respect to 0 V. **Signal 2** is inverted compared to **Signal 1**. The signals received at the far end of a long cable carrying the microphone signal are shown below. The noise interfering with both signals is the same.



Signal 1 is connected to input A of a summing amplifier. **Signal 2** is passed through an amplifier with a voltage gain of –1 and then connected to input B of the summing amplifier, as shown in the diagram below.



(i) What is the effect of the amplifier with a voltage gain of –1 on **Signal 2**?

.....

.....

(ii) Explain how this arrangement is able to reduce significantly the effect of noise, picked up by the long cable, on the microphone signal.

.....

.....

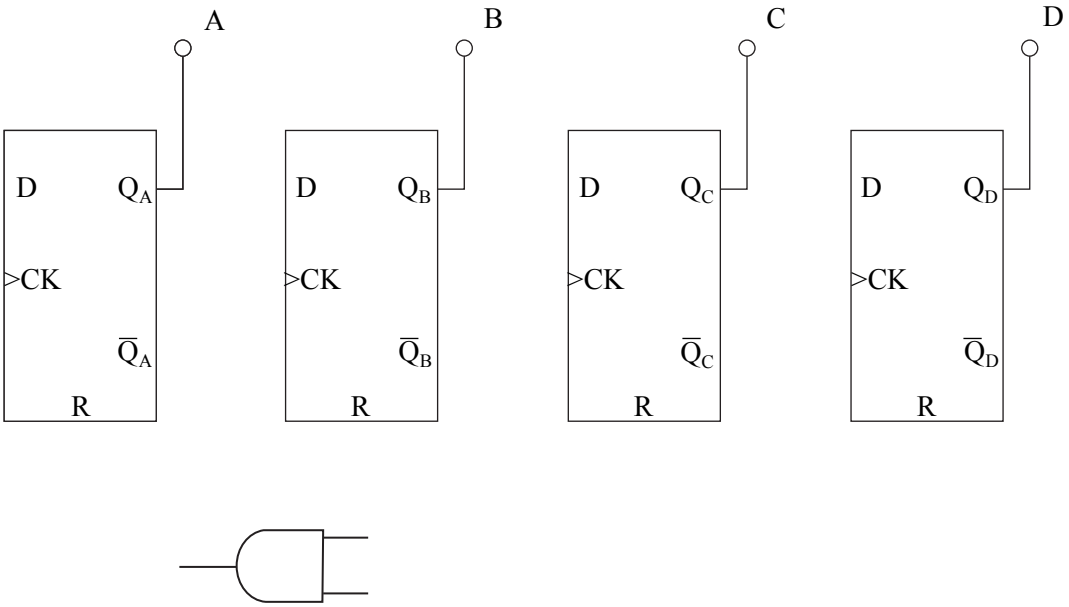
.....

(5 marks)

9

Turn over ▶

5 (a) Complete the circuit diagram below to show how four D-type flip-flops can be used to form a modulo 10 counter, with outputs A, B, C and D.



(4 marks)

(b) An automatic bread maker has 10 discrete processes which are listed below. The processes are controlled by the modulo 10 counter.

number	process	action
0	OFF	Add ingredients
1	Mix ingredients	Motor on
2	Warm ingredients	Heater on
3	Pause	Add yeast
4	Mix dough	Motor on
5	Warm ingredients	Heater on
6	Mix dough	Motor on
7	Warm ingredients	Heater on
8	Cook	Heater on
9	STOP	Alert that bread is cooked

Explain why the Boolean expression for the heater being on is

$$\mathbf{\overline{D}.\overline{C}.B.\overline{A} + \overline{D}.C.\overline{B}.A + \overline{D}.C.B.A + D.\overline{C}.\overline{B}.\overline{A}}$$

.....

.....

.....

.....

(2 marks)

(c) Show that the expression simplifies to

$$\mathbf{\overline{A}.\overline{C}.(D \oplus B) + \overline{D}.C.A}$$

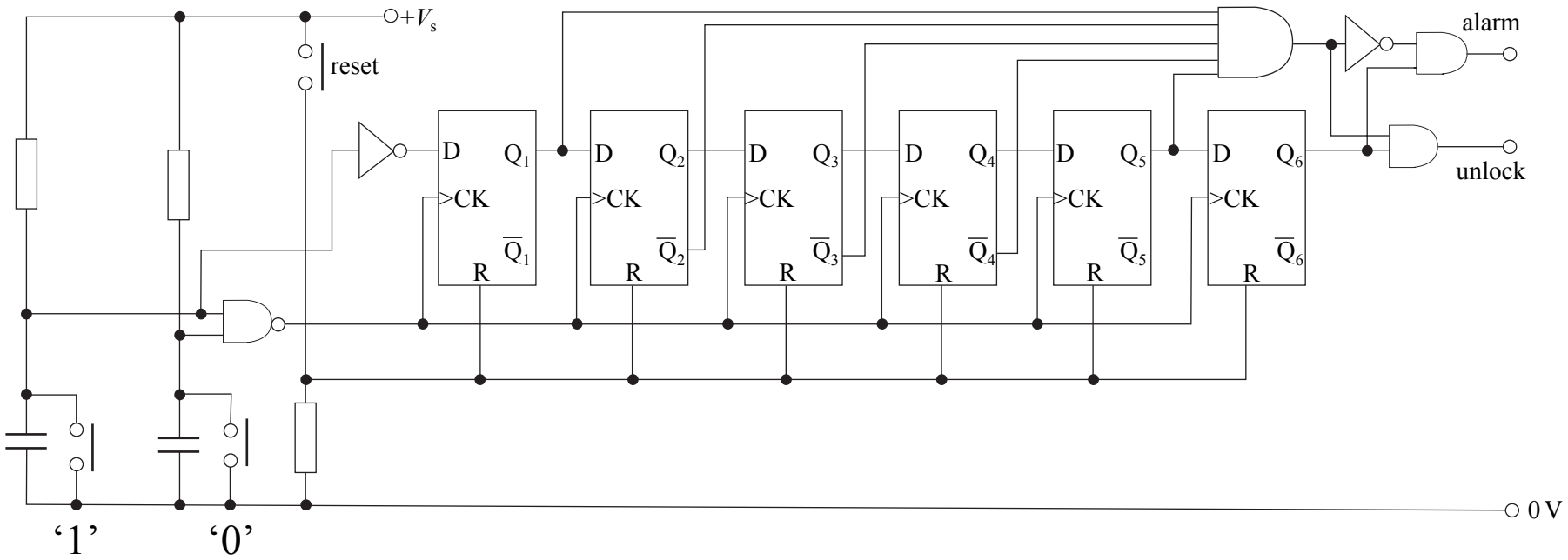
(3 marks)

9

NO QUESTIONS APPEAR ON THIS PAGE

Use the diagram printed on the reverse of this page to answer Question 6 on **page 15**. Detach this sheet and study the diagram before attempting to answer Question 6.

The circuit diagram for a combination lock is shown below. It consists of a 6-bit shift register plus additional logic circuits.



To operate the lock, the circuit is first reset and then a binary number is entered by pressing the ‘1’ and ‘0’ switches. If an incorrect number is entered an alarm is sounded.

Use the diagram printed on **page 14** to answer Question 6.
Detach **page 14** and study the diagram before answering Question 6.

6 (a) Explain how a shift register operates.

.....

.....

.....

.....

(4 marks)

(b) Each of the input switches has an associated resistor and capacitor circuit.
Explain the function of this circuit.

.....

.....

(1 mark)

(c) Explain what will happen when the '1' input switch is pressed.

.....

.....

.....

(2 marks)

(d) State a binary number that can be entered for the system to unlock.
Explain your reasoning.

.....

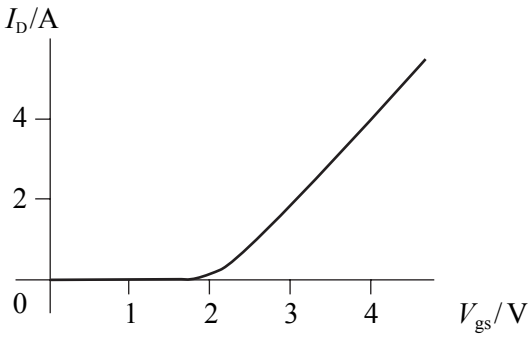
.....

.....

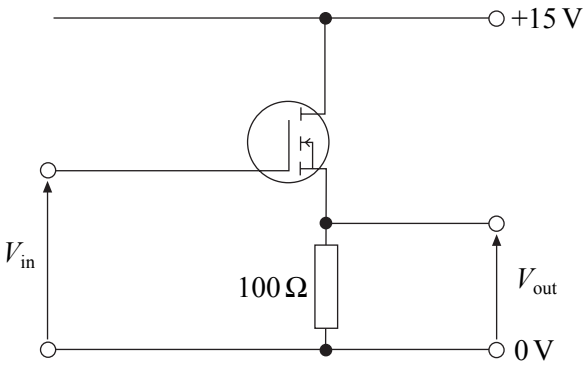
(2 marks)

9

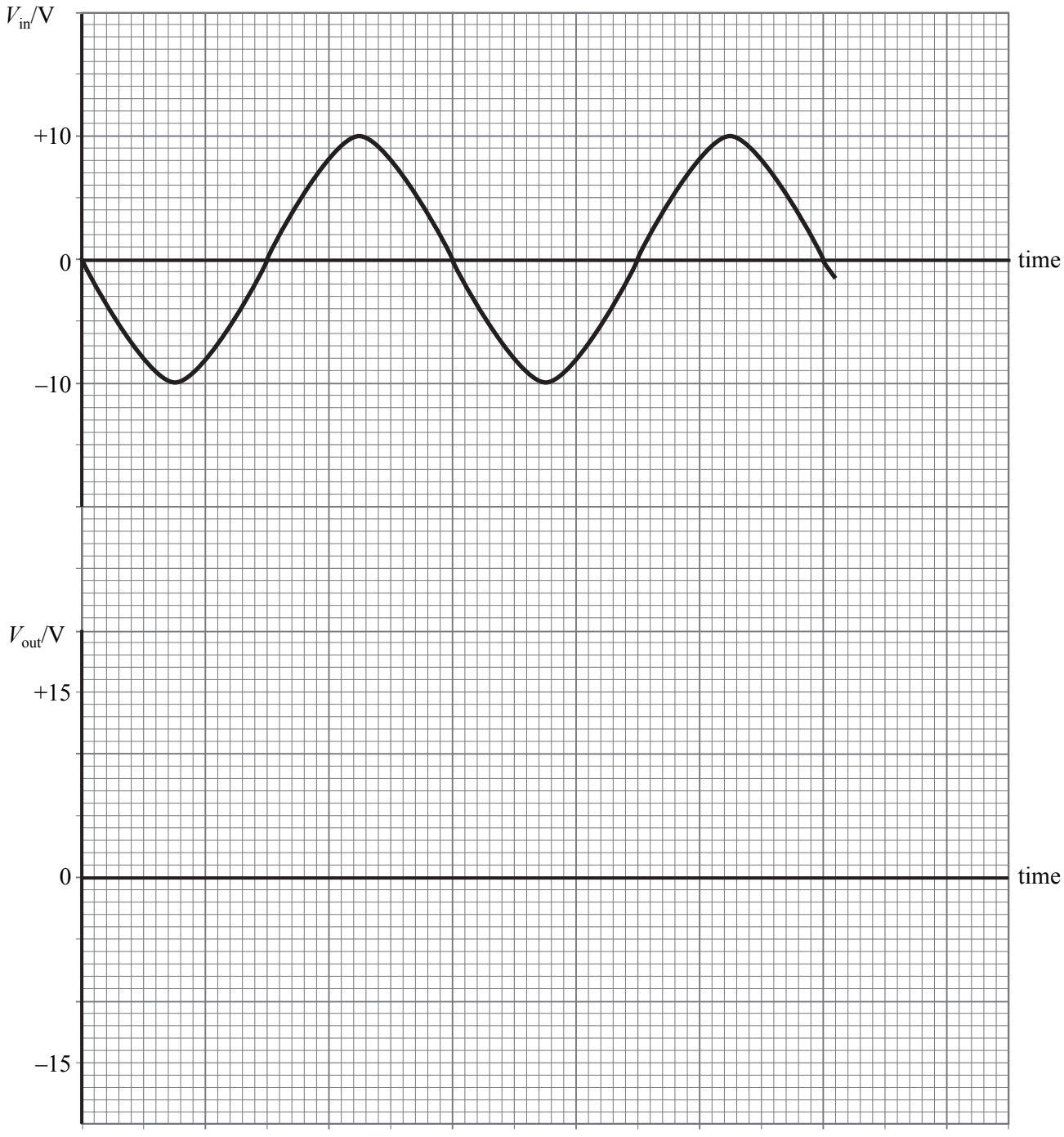
7 The I_D/V_{gs} characteristic for a power MOSFET is shown below.



The MOSFET is connected as a source follower as shown in the circuit below.



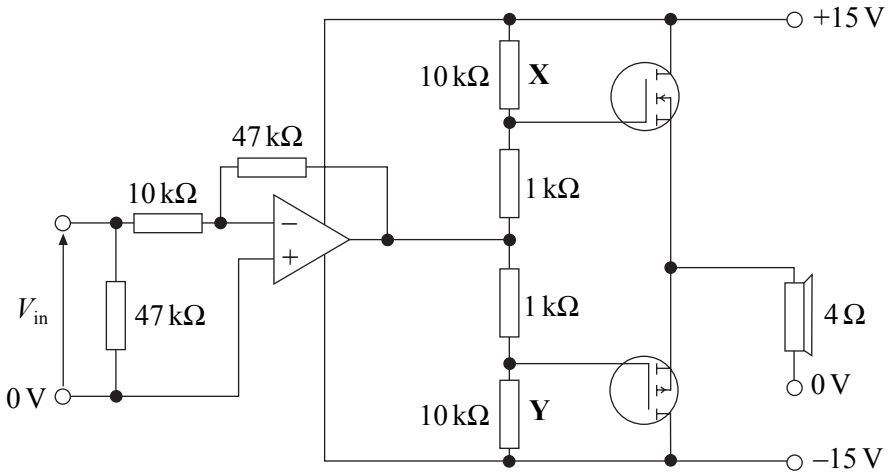
(a) An alternating voltage of 10 V amplitude is supplied to the input of the source follower as shown in the graph below.
Sketch a graph on the axes to show the corresponding output voltage.



(3 marks)

QUESTION 7 CONTINUES ON THE NEXT PAGE

A matched pair of n-channel and p-channel MOSFETs are connected as shown in the circuit diagram below.



(b) (i) What is the name given to this arrangement of MOSFETs?

.....

(ii) Estimate the voltage gain of this circuit, showing your working.

.....

.....

(3 marks)

(c) At low volume levels, the output signal is distorted.

(i) State the name of this type of distortion.

.....

(ii) Explain how this distortion arises.

.....

.....

.....

(iii) With no input signal, estimate the reading that you would observe on an ammeter placed in the drain circuit of either MOSFET.

.....

(4 marks)

(d) This distortion can be reduced by decreasing the value of the resistors **X** and **Y**. Suggest, with reasoning, suitable new values for these resistors.

.....

.....

.....

(3 marks)

(e) State another way in which the low volume distortion can be reduced.

.....

.....

(2 marks)

(f) Estimate, showing your reasoning, the maximum undistorted rms output power to the speaker.

.....

.....

.....

(3 marks)

18

END OF QUESTIONS

THERE ARE NO QUESTIONS PRINTED ON THIS PAGE