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OXFORD CAMBRIDGE AND RSA EXAMINATIONS

Friday 9 June 2023 – Afternoon

Level 3 Cambridge Technical in Engineering

05822/05823/05824/05825/05873

Unit 4: Principles of electrical and electronic engineering

Time allowed: 1 hour 30 minutes plus your additional time allowance

You must have:

the Formula Booklet for Level 3 Cambridge Technical in Engineering (with this document)

a ruler (cm/mm)

a scientific calculator

the Insert for Question 1(a)

Please write clearly in black ink.

Centre number								
Candidate number								
First name(s)								
Last name								
Date of birth	D	D	M	M	Y	Y	Y	Y

READ INSTRUCTIONS OVERLEAF

INSTRUCTIONS

Use black ink. You can use an HB pencil, but only for graphs and diagrams.

Write your answer to each question in the space provided. If you need extra space use the lined pages at the end of this booklet. The question numbers must be clearly shown.

Answer ALL the questions.

Where appropriate, your answer should be supported with working.

Give your final answers to a degree of accuracy that is appropriate to the context.

INFORMATION

The total mark for this paper is 60.

The marks for each question are shown in brackets [ ].

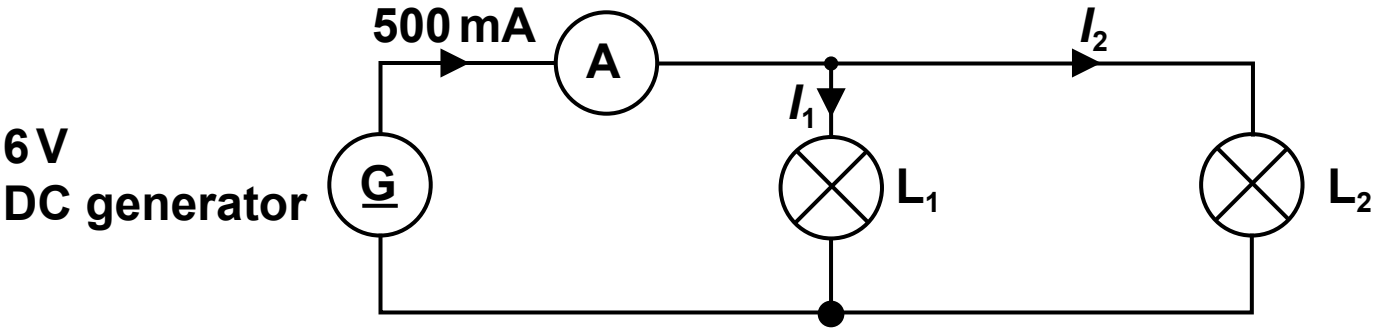
ADVICE

Read each question carefully before you start your answer.

1 A bicycle has front and back lights powered by a 6 V DC generator of negligible internal resistance.

The front and back lights use filament lamps. A mechanic uses a multimeter to test the circuit while the bicycle wheel is turning the generator. FIG. 1 shows the circuit diagram of the bicycle lighting system and the multimeter being used as an ammeter.

FIG. 1



(a) The multimeter is used as an ammeter to measure the current from the DC generator.

The current from the DC generator is designed to be 500 mA.

FIG. 2a on the Insert shows a multimeter with the dial in the off position.

Draw an arrow ON FIG. 2b on the Insert to show the correct position of the dial to precisely measure the current from the DC generator. [1]

(b) The power dissipated by L_1 is 0.6 W.

(i) Calculate the energy dissipated by L_1 in 5 minutes.

energy dissipated by L_1 = _____ J [2]

(ii) Calculate the current, I_1.

current, I_1 = _____ A [1]

(iii) Calculate the resistance of L_1.

resistance of L_1 = _____ Ω [1]

(c) Calculate the resistance of L_2.

resistance of L_2 = _____ Ω [2]

(d) Calculate the power dissipated by L_2.

power dissipated by L_2 = _____ W [1]

2 An inductor and resistor are connected in series to an alternating current (AC) generator.

(a) Explain what is meant by alternating current.

_____

_____

_____

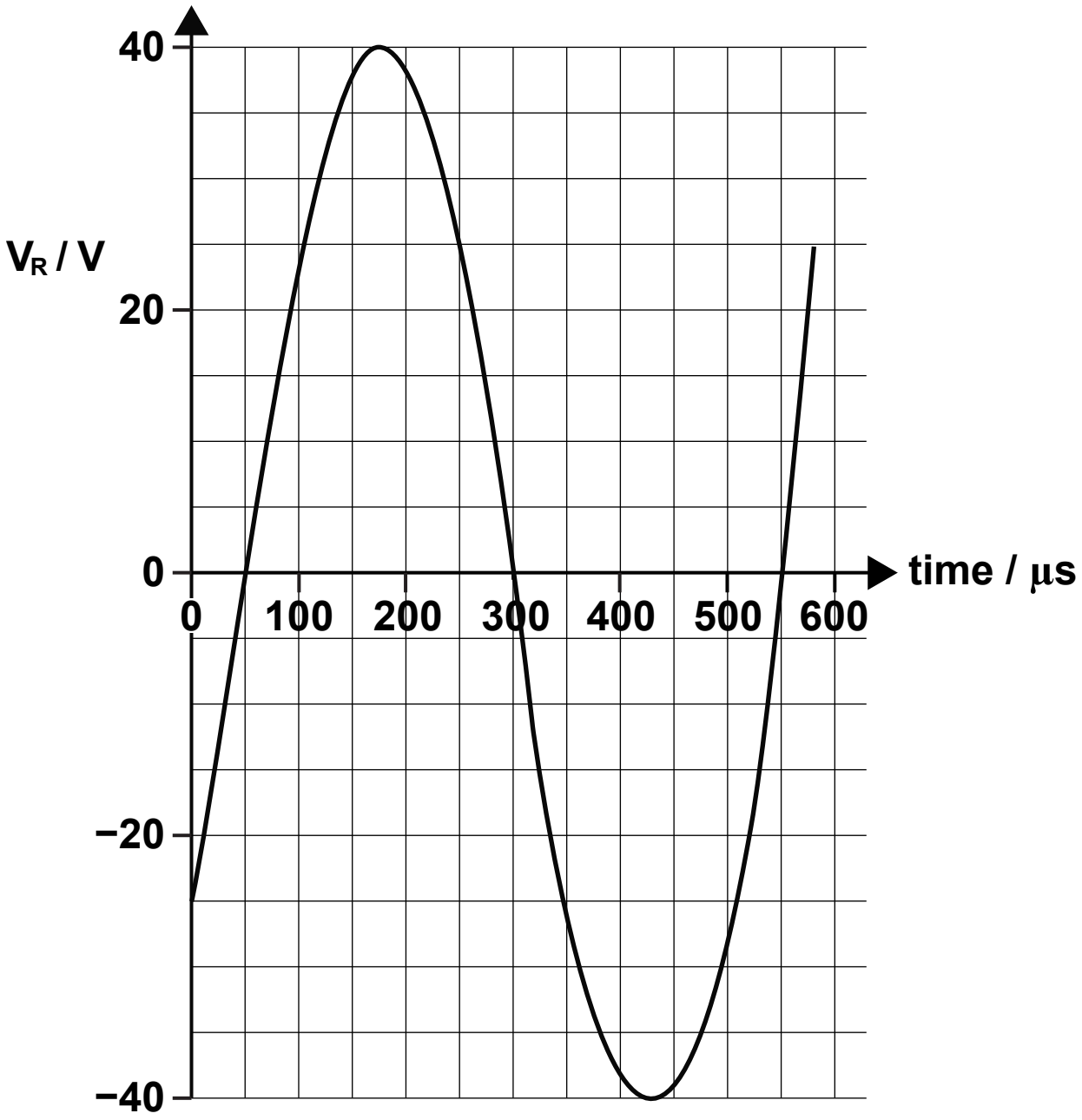
_____ **[2]**

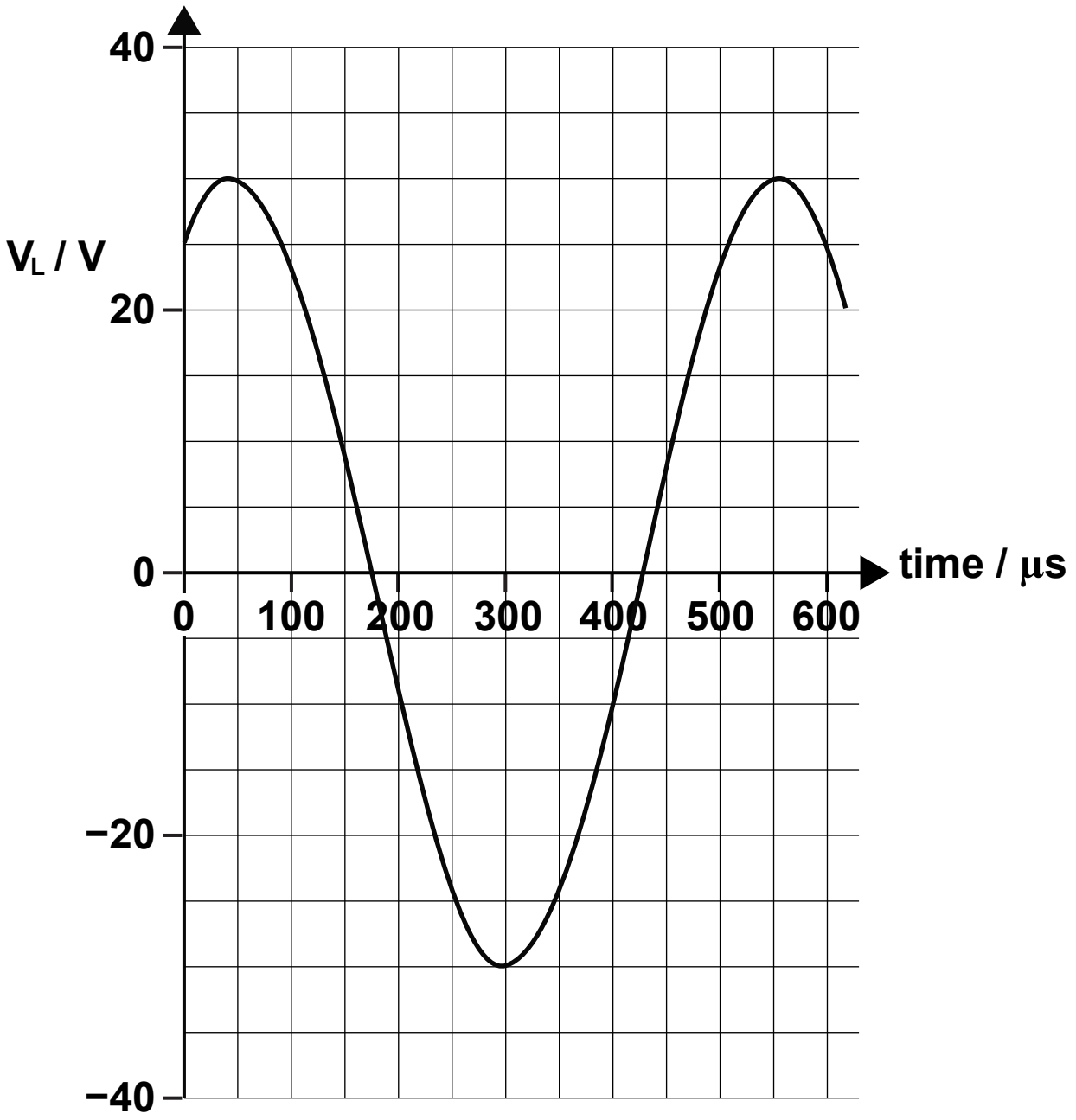
(b) Draw a circuit diagram of the inductor and resistor connected in series to an alternating current (AC) generator.

Label all components. [2]

(c) Graphs of voltage against time for the voltage across the resistor V_R and the voltage across the inductor V_L are shown in FIG. 3.

FIG. 3





(i) Find the amplitude of V_R from the graph in FIG. 3.

amplitude of V_R = _____ V [1]

(ii) Find the period of V_R from the graph in FIG. 3.

period of V_R = _____ μs [1]

(iii) Calculate the frequency of V_R.

frequency of V_R = _____ Hz [2]

(iv) Calculate the phase difference between V_R and V_L in degrees.

phase difference between V_R and V_L = _____ ° [2]

(v) Calculate the phase difference between V_R and V_L in radians.

phase difference between V_R and V_L = _____ rad [1]

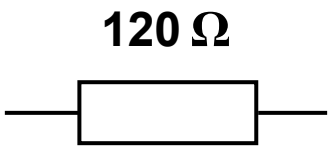
3 An engineer is testing a series-wound self-excited DC generator connected to a 120 Ω resistor.

The resistance of the armature is 25 Ω and the resistance of the field winding is 18 Ω.

(a) Draw the circuit diagram of a series-wound self-excited DC generator ON FIG. 4 and show how it is connected to the resistor.

Label the field winding and the armature. [2]

FIG. 4



(b) When the generator is connected to the 120 Ω resistor the voltage at the output is 8.2 V.

(i) Calculate the current in the 120 Ω resistor.

current in the 120 Ω resistor = _____ A [1]

(ii) Calculate the EMF, *E*, in the armature.

Give the units of your answer.

EMF generated in the armature, *E* = _____ [3]

(c) When the 120 Ω resistor is replaced by a power supply, the series-wound DC generator works as a series-wound DC motor.

(i) State the difference between a motor and a generator.

_____

_____

_____

_____ **[2]**

(ii) When the motor is operating from a supply of 24 V the EMF in the armature is 17 V.

Calculate the current in the armature, I_a.

I_a = _____ **A [2]**

(iii) The engineer needs a motor to make a conveyer belt move at a fairly constant speed regardless of the load on the conveyor belt. A series-wound self-excited DC motor is not the best choice of motor for this application.

Suggest a better choice of DC motor for the conveyor belt. Explain your answer. Refer to the characteristics of the motor.

_____

_____

_____ **[2]**

4 A stabilised power supply is used to provide the steady 19 V DC supply for a laptop computer from the 230 V AC mains supply.

(a) Complete the block diagram of a stabilised power supply shown in FIG. 5 opposite.

Choose from the terms below. [5]

3-wire Delta	**AC input**	**DC output**
smoothing circuit	**stabilising circuit**	**transformer**

(b) State the function of the rectifier.

_____

_____ **[1]**

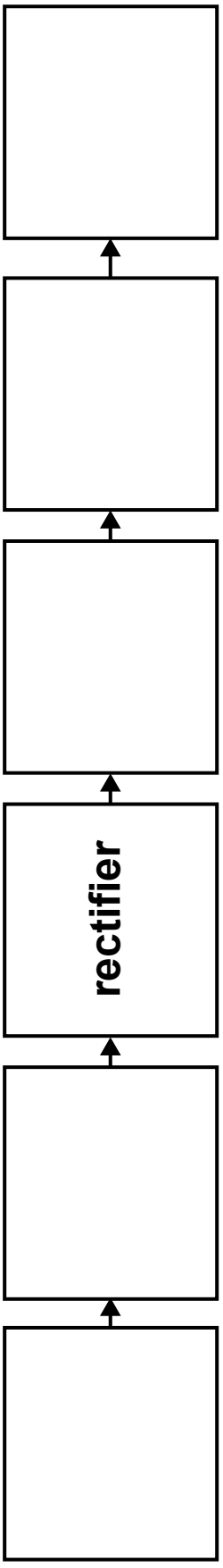
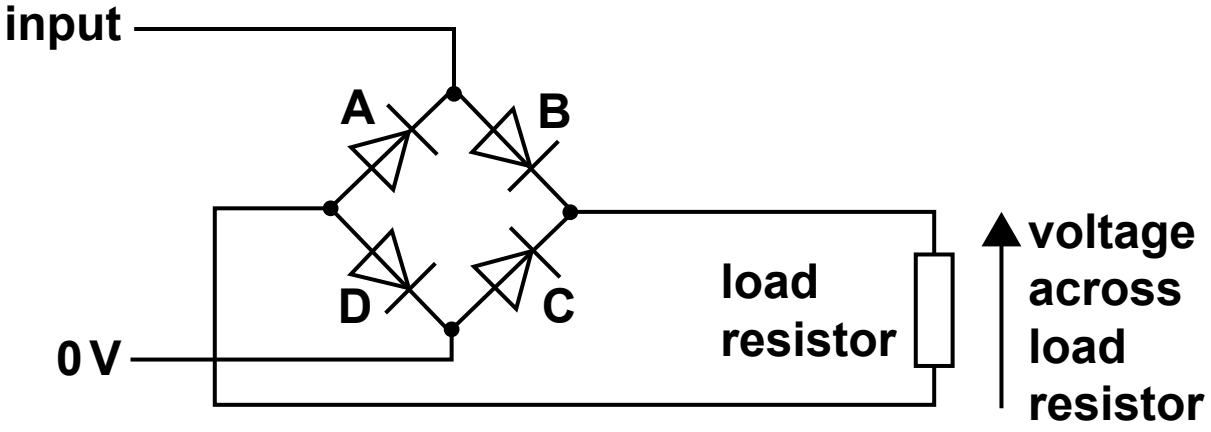


FIG. 5

(c) A rectifier is shown in FIG. 6.

FIG. 6



(i) Complete the sentences below about the rectifier in FIG. 6 using the most appropriate term in each gap.

Choose terms from the following list.

Each term may be used once, more than once or not at all. [3]

A and B	A and C	A and D	all
B and C	B and D	C and D	no

When the voltage at the input is 24 V,

_____ diodes are conducting.

When the voltage at the input is 0 V,

_____ diodes are conducting.

When the voltage at the input is −24 V,

_____ diodes are conducting.

(ii) **The input voltage to the rectifier is shown in FIG. 7a.**

Show how the full wave bridge rectifier operates by drawing the voltage across the load resistor on the grid in FIG. 7b. [2]

FIG. 7a

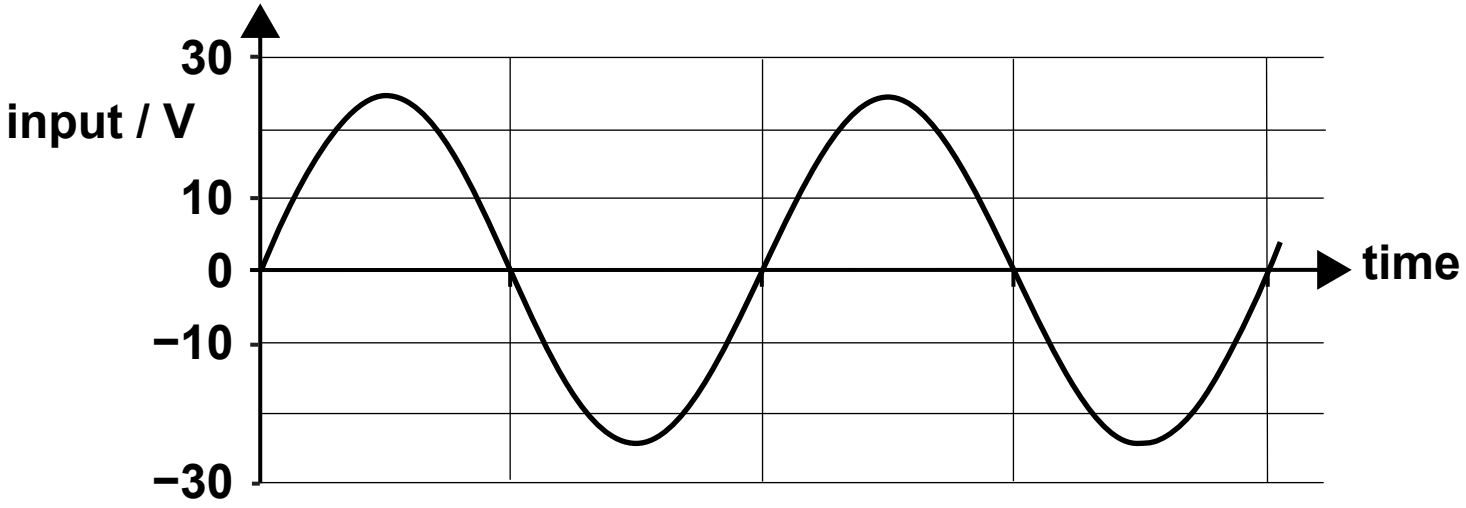
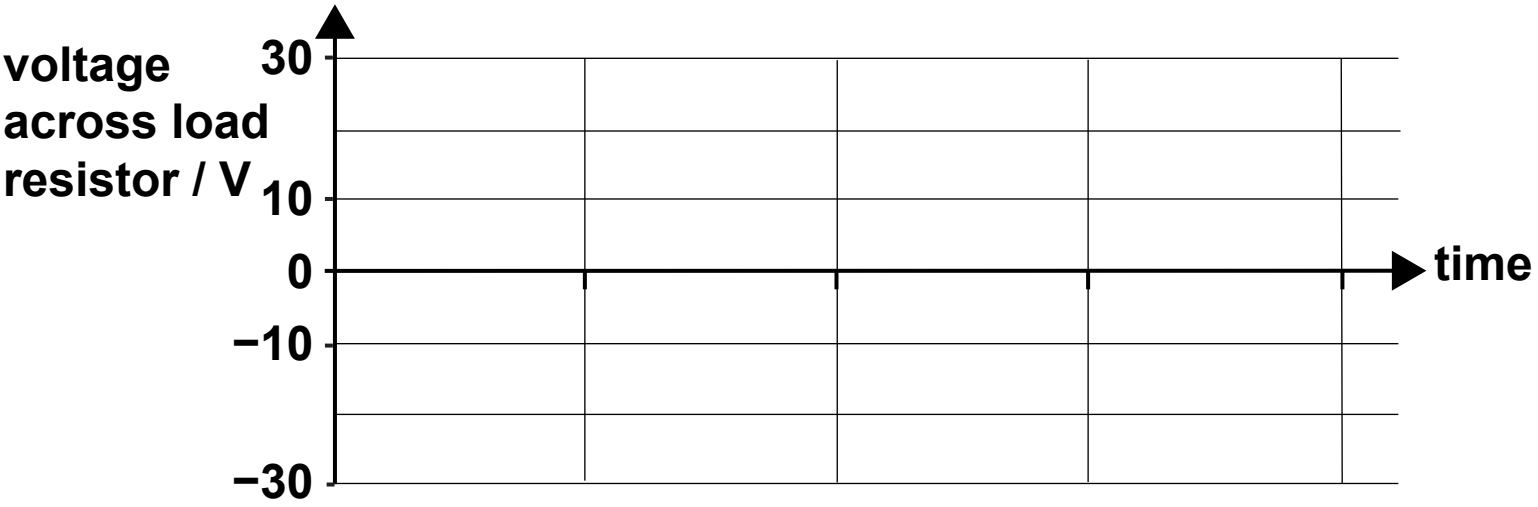


FIG. 7b



5 The block diagram of a system for measuring temperature is shown in FIG. 8.

FIG. 8

(a) The equation for voltage gain of a non-inverting op-amp amplifer is:

$$\text{Voltage gain} = \frac{V_{out}}{V_{in}} = 1 + \frac{R_F}{R_2}$$

(i) When the voltage from the temperature sensor is 2.2 V the voltmeter reads 5.5 V.

Calculate the voltage gain of the amplifier.

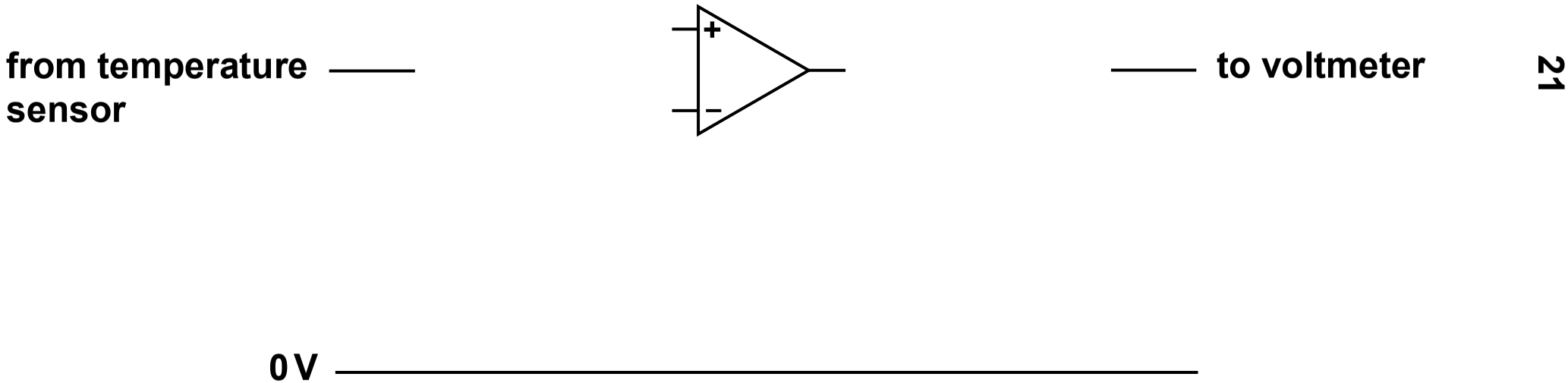
voltage gain of the amplifier = _____ [1]

(ii) The system in FIG. 8 uses a non-inverting amplifier.

Complete the circuit diagram in FIG. 9 opposite of a non-inverting amplifier.

Label the components with suitable values. [5]

FIG. 9



(b) The current from the temperature sensor must be low to obtain an accurate reading.

State the property of an op-amp that ensures the current from the sensor is low.

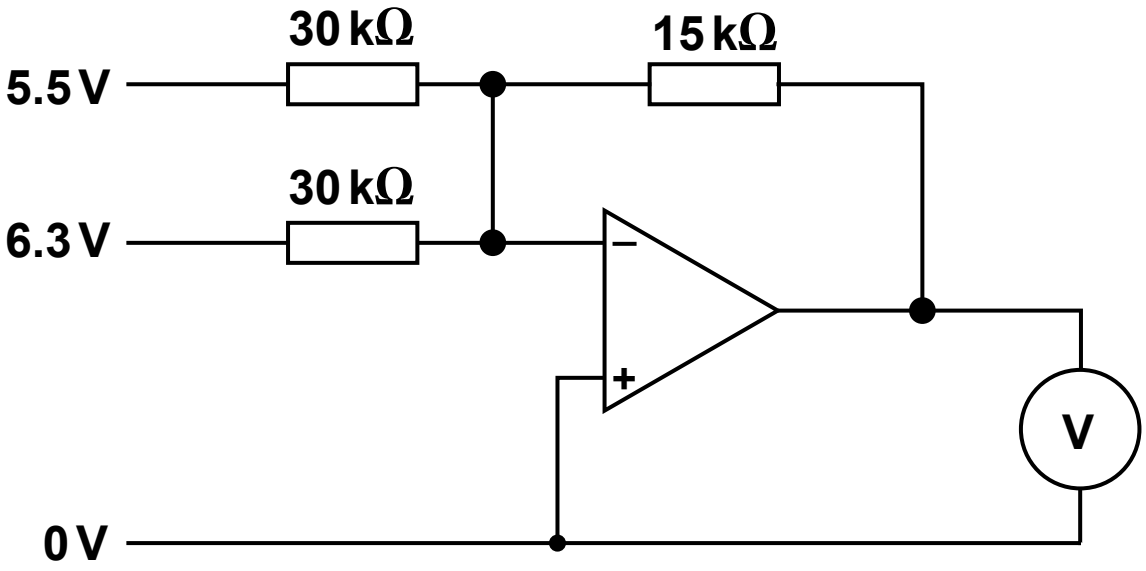
_____

_____ **[1]**

(c) The circuit in FIG. 10 shows a summing amplifier being used to combine the signals from two temperature sensors.

Calculate the voltage shown on the voltmeter in FIG. 10.

FIG. 10



voltage shown on voltmeter = _____ V [3]

6 This question is about digital electronic circuits.

(a) State the meaning of DIGITAL in the term DIGITAL ELECTRONIC CIRCUITS.

_____

_____ **[1]**

(b) This is the truth table of a logic system with inputs F and G and output P.

F	G	P
0	0	0
0	1	1
1	0	0
1	1	0

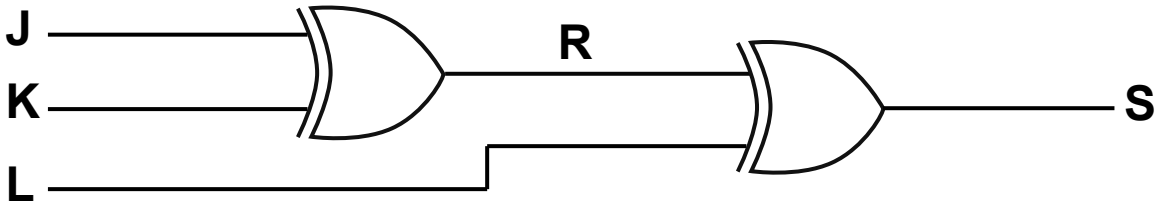
Draw a circuit using logic gates to obey this truth table.

You may use any logic gates in your design.

Label the inputs F and G. Label the output P. Use the space below. [2]

(c) A logic circuit is shown in FIG. 11.

FIG. 11



(i) Name the type of logic gate used in FIG. 11.

_____ [1]

(ii) Put a ring around the Boolean expression for the first logic gate in FIG. 11. [1]

$R = J + K$ $R = \overline{J + K}$ $R = J \cdot K$ $R = \overline{J \cdot K}$ $R = J \oplus K$

(iii) Complete the truth table for the logic circuit in FIG. 11. [3]

J	K	L	R	S
0	0	0		

END OF QUESTION PAPER

ADDITIONAL ANSWER SPACE

If additional answer space is required, you should use the following lined pages. The question numbers must be clearly shown – for example, 2(a) or 4(b).