OCR
RECOGNISING ACHIEVEMENT

OXFORD CAMBRIDGE AND RSA EXAMINATIONS

Advanced GCE

D&T: SYSTEMS AND CONTROL TECHNOLOGY 2525/01

UNIT 8 Systems and Control Technology 2

Papers 2525/01 and 2525/02 should be available to candidates for the full 2 hour 30 minutes examination session

Monday **30 JANUARY 2006** Morning 1 hour

This paper is to be taken with 2520/02 in the same examination session of 2 hours 30 minutes

Additional materials:
8 page Answer booklet

TIME Approximately 1 hour should be spent on this paper (Paper 2525/01)

INSTRUCTIONS TO CANDIDATES

This paper is to be taken with 2525/02 in the same examination session of 2 hours 30 minutes.

This paper (2525/01) contains **six** questions.

- You are required to answer **two** questions.
- Please note that the instruction 'discuss' denotes that you should:
  - identify **three** relevant issues/points raised by the question;
  - explain why you consider these issues to be relevant;
  - use **two** specific examples/evidence to support your answer.

INFORMATION FOR CANDIDATES

- The intended mark for each question or part question is given in brackets [ ].
- The total number of marks for 2525/01 and 2525/02 is **120**.
  (2525/01 = 48 marks, 2525/02 = 72 marks)

This question paper consists of 12 printed pages and an insert.

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2525/01

You are required to answer **two** questions.

Answer questions in the separate answer booklet.

You are advised to spend 60 minutes on this paper.

Questions 1 and 2 are electrical/electronic systems questions.

1 The design of an electronic clock requires an accurate 1Hz clock pulse.

(a) The circuit in Fig. 1 was chosen.

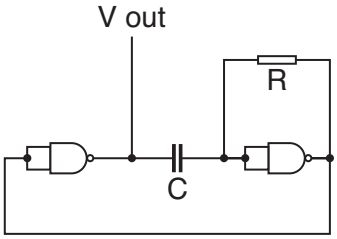


Fig. 1

(i) Name the logic gates shown in Fig. 1. [1]

(ii) Name a logic gate that could directly replace those shown in Fig. 1. [1]

(b) When the output of the circuit in Fig. 1 was checked on an oscilloscope it was not exactly 1Hz.

State the reason why the output was not exactly as expected. [1]

(c) The 1Hz clock pulse is fed into a 4-bit binary counter. The design requires the binary counter to count ten clock pulses between resets.

(i) State the 4-bit binary code for decimal 10. [1]

(ii) Draw a circuit to show how the counter can be made to reset after ten pulses. Label the outputs of the counter. [3]

(d) Fig. 2 shows a D-type flip-flop.

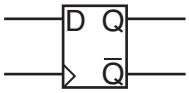


Fig. 2

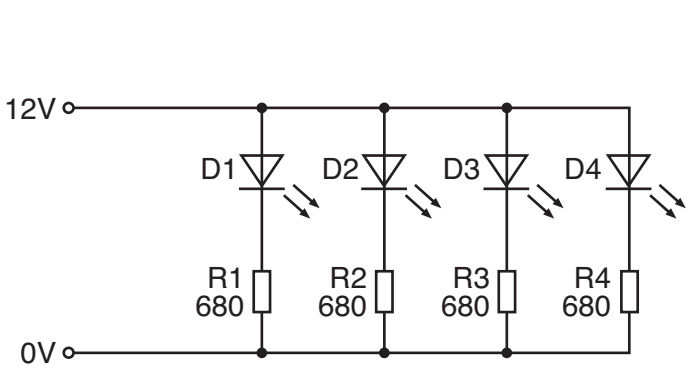
(i) Show, with the aid of a diagram, how the D-type can be made to toggle. [2]

(ii) Draw a 3-bit binary up-counter using only D-type flip-flops.

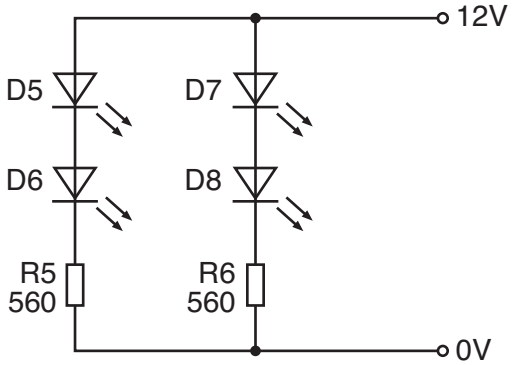
Label all connections and show both LSB (Least Significant Bit) and MSB (Most Significant Bit). [4]

(e) To increase visibility each output LED of the counter was replaced by a cluster of four LEDs.

Fig. 3 shows two possible arrangements.



Circuit A



Circuit B

Fig. 3

(i) Give the reason why circuit **B** is more efficient than circuit **A**. [1]

(ii) The forward voltage drop across each LED is 2.2 volts.
Calculate the forward current in each arm of circuit **B**. [2]

(f) Discuss the implications for the designer of choosing appropriate electronic display systems. [8]

[Total : 24]

2 Rechargeable batteries can be very useful on field trips to power portable electronic equipment.

(a) Fig. 4 shows a charging system to provide a 5 volt DC output 24 hours a day.

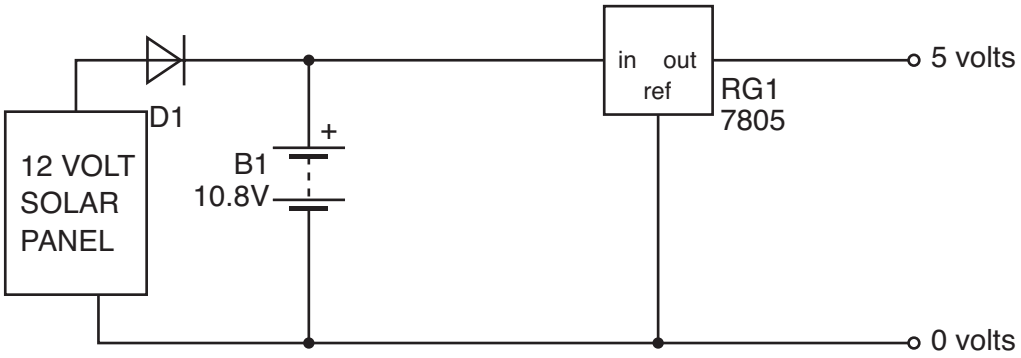


Fig. 4

(i) State the purpose of the Ni-Cad battery B1. [1]

(ii) State the function of diode D1. [1]

(iii) Data for the solar panel are given in the box below.

Solar Panel	
Nominal daylight output	12v
Bright sun output	14.2v
Maximum output power	3.5W

State the expected maximum and minimum input voltages to the 7805 voltage regulator RG1. [2]

(b) The solar panel is mounted on a turntable that follows the path of the sun.
Two LDRs, mounted in black tubes, are positioned either side of the solar panel, as shown in Fig. 5 .

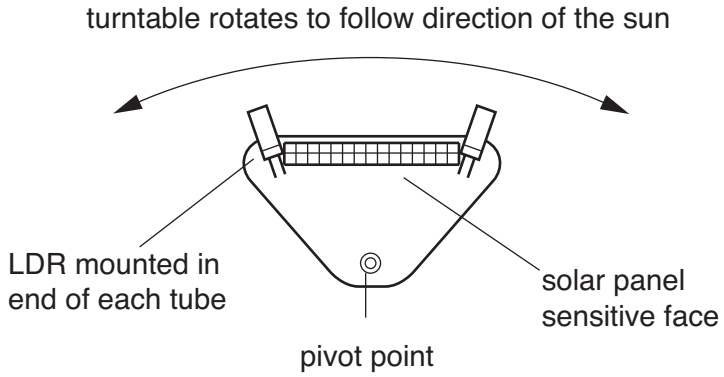


Fig. 5

Explain why the LDRs are mounted in black tubes. [2]

(c) Fig. 6 shows the circuit diagram of the turntable control system.
The stepper motor controller drives the motor when one of the inputs goes high.
Both operational amplifiers are single supply.

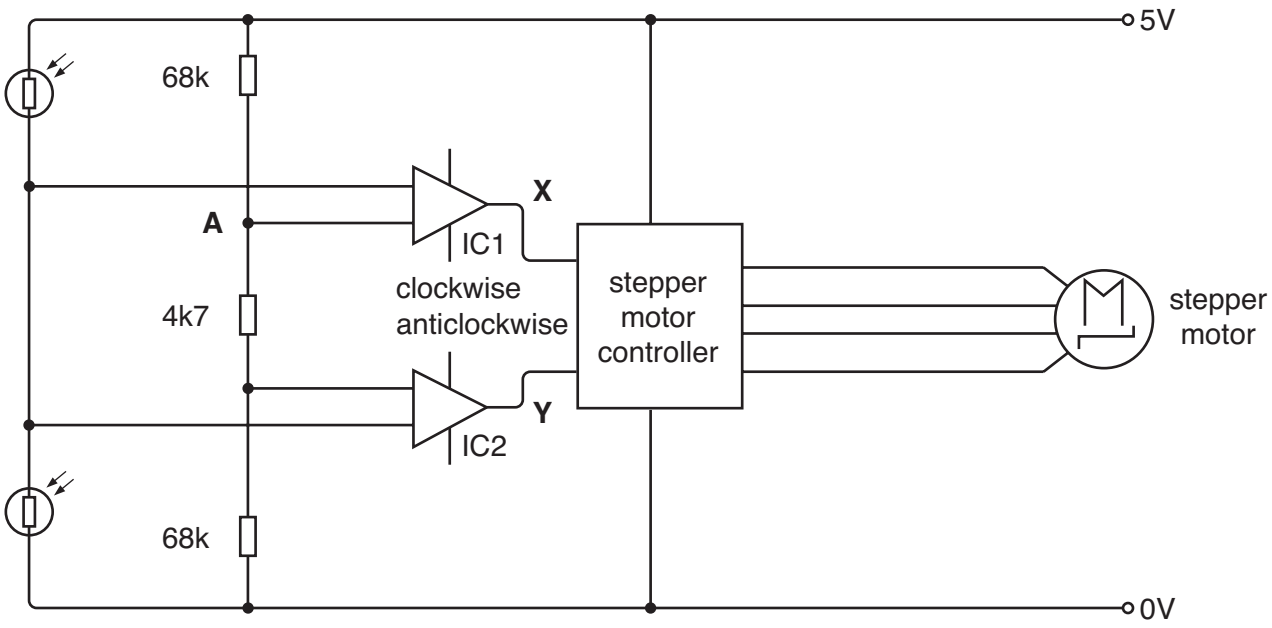


Fig. 6

(i) Calculate the voltage at point **A**. [2]

(ii) Explain how the circuit tracks the sun. [4]

(iii) Describe the effect on outputs **X** and **Y** if a cloud suddenly obscures the sun. [4]

(d) Discuss the implications of using sources of sustainable electrical energy. [8]

[Total : 24]

Questions 3 and 4 are mechanical systems questions.

3 Stepper motors are used extensively in computer hardware. Fig. 7 shows a computer printer.

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Details:

An image of a printer

Fig. 7

(a) (i) Name another application where a stepper motor is used. [1]

(ii) State two advantages of a stepper motor over a DC motor. [2]

(b) Fig. 8 shows a toothed belt.

Fig. 8

(i) Give one benefit of using a toothed belt drive in a computer printer. [1]

(ii) Name another application where a toothed belt is used. [1]

(c) The table below shows the specification of a stepper motor.

Voltage:	12v
Step angle:	1.8°
Output shaft diameter:	3mm
Current / coil:	160mA
Phase (coil) resistance:	75 Ω
Holding torque:	81.4Nmm

(i) Explain what is meant by the term 'step angle'. [2]

(ii) The output shaft of the stepper motor is designed to run at 60rpm.
Using notes and sketches, design a suitable compound train gearbox to increase the final output speed to 9600rpm. [5]

(iii) Calculate the torque at the output shaft of the gearbox for an input torque of 81.4Nmm.
Assume 100% efficiency. [2]

(d) Nylon bearings are likely to be used to support the shafts in the gearbox.
Explain why. [2]

(e) Discuss the implications of built-in obsolescence in domestic products. [8]

[Total : 24]

4 Lifts are used to move goods or people from floor to floor.

Fig. 9 shows a model for the cable mechanism of a lift.

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Details:

A diagram of a cable operated lift mechanism

Fig. 9

(a) State two advantages of using a worm and pinion system as modelled in Fig. 9. [2]

(b) The table below gives the production specification for the actual cable mechanism.

q	Winding drum pinion gear (40 teeth)
r	Worm gear
s	Spur gear (30 teeth)
t	Drive motor pinion gear (18 teeth)

(i) State the gear ratio of the worm and pinion. [1]

(ii) Calculate the gear ratio between the motor and the winding drum. [2]

(c) (i) State the type of bearing used for the actual drive motor shaft. [1]

(ii) Explain how the bearing used for the drive motor shaft is designed to cope with its load. [2]

(d) The lift cable is 35mm diameter and the full lift load has a mass of 1850kg.

(i) The cable will have a factor of safety. Explain the term 'factor of safety". [2]

(ii) Calculate the stress in the lift cable once operating speed has been reached. Assume $g = 10 m/s^2$ [4]

(e) Explain why a counterbalance is used in lift systems. [2]

(f) Discuss the problems of lift safety in high-rise buildings. [8]

[Total : 24]

Questions 5 and 6 are pneumatic systems questions.

5 **(a)** Fig. 10 shows a set of sliding doors often used in shops.

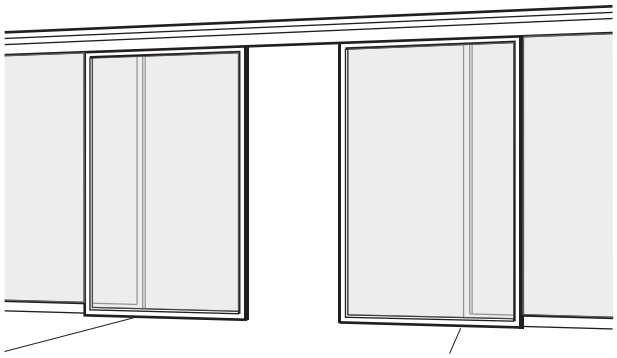

Fig. 10

State **three** design criteria for a set of sliding doors used in a shop. [3]

(b) Fig. 11 shows a prototype pneumatic circuit for opening and closing a pair of manually controlled sliding doors.

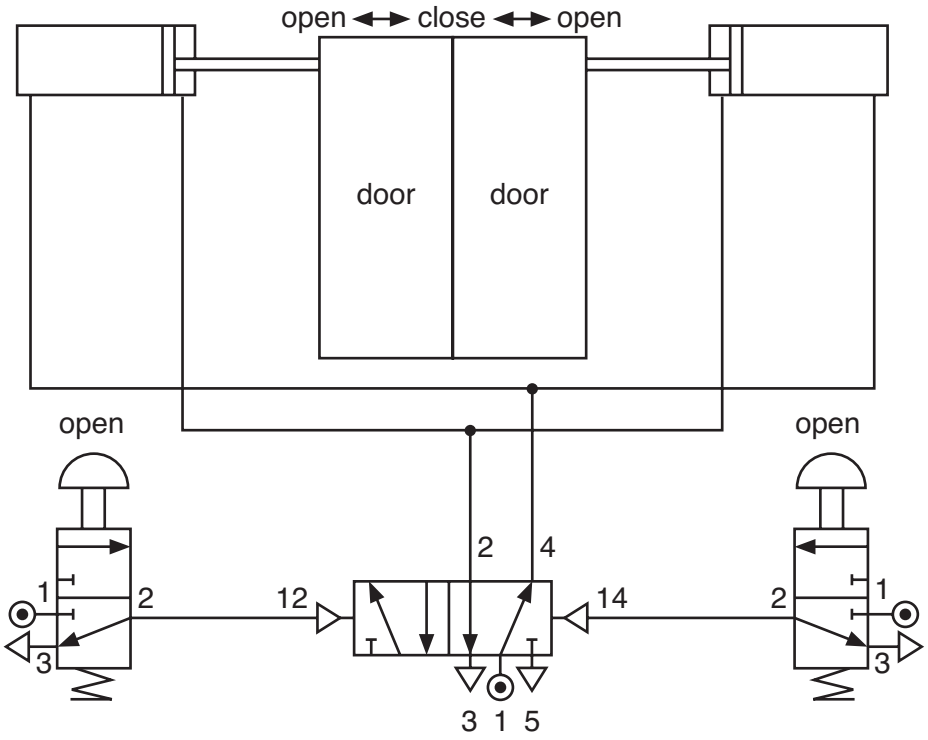

Fig. 11

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(i) The doors need to open automatically.
A passive infra-red sensor detects people approaching the doors from either side and causes a relay to energise.
Use notes and sketches to show how the energising of a relay will open the doors automatically. [4]

(ii) The 'open' pushbutton is to be retained for use in an emergency and is to operate in parallel with the automatic control.
Draw and name the device that will allow the two parts of the circuit to operate in parallel. [2]

(iii) After a suitable delay, the doors need to close automatically.
Use notes and sketches to show a suitable sub-circuit that will close the doors after a delay. [4]

(c) The force required to close **each** door was found to be 960N and the air is supplied at 0.75N/mm^2.
Calculate the diameter of both cylinders. [3]

(d) Discuss the implications for the manufacturer of their automatic doors being used in public places. [8]

[Total : 24]

6 A packaging company uses pneumatics throughout its factory to stamp information on the end of food boxes, e.g. the 'use by' date.
Fig. 12 shows the pneumatic system for stamping the boxes.

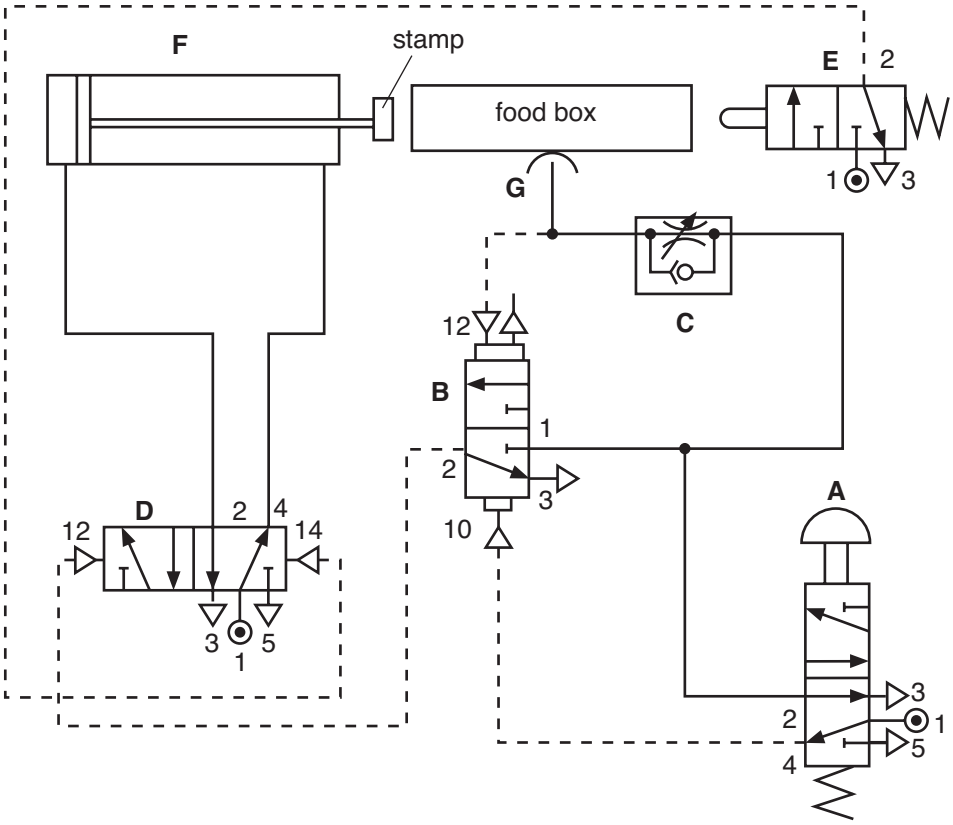

Fig. 12

(a) **(i)** Name the operator used on valve **E**. [1]

(ii) Name component **C** in this circuit. [1]

(iii) Explain how cylinder **F** is made to in-stroke. [2]

(b) The food box shown in Fig. 12 can be damaged by the piston out-stroking too quickly.
Explain, with the aid of notes and sketches, how the out-stroke can be slowed down without changing the in-stroke speed. [4]

[Turn over

(c) Use notes and sketches to show a circuit that will automatically remove the food box from the stamping position. [4]

(d) Calculate the volume of air, in litres/min, consumed by the piston on its out-stroke when:

- the gauge pressure is 6 bar;
- the piston area is 314mm^2;
- the piston stroke length is 50mm;
- the piston does 40 cycles per minute; and
- 1000cm^3 = 1 litre. [4]

(e) Discuss the implications of combining different manufacturing processes within a production system. [8]

[Total : 24]