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## DESIGN & TECHNOLOGY

0445/42

Paper 4 Systems & Control

May/June 2022

1 hour

You must answer on the question paper.

No additional materials are needed.

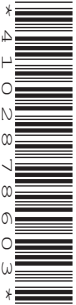
### INSTRUCTIONS

- Section A: answer **all** questions.
- Section B: answer **one** question.
- Use a black or dark blue pen. You may use an HB pencil for any diagrams or graphs.
- Write your name, centre number and candidate number in the boxes at the top of the page.
- Answer in the space provided.
- Do **not** use an erasable pen or correction fluid.
- Do **not** write on any bar codes.
- You may use a calculator.

### INFORMATION

- The total mark for this paper is 50.
- The number of marks for each question or part question is shown in brackets [ ].
- All dimensions are in millimetres.

This document has **20** pages. Any blank pages are indicated.



Section A

Answer **all** questions in this section.

1 Fig. 1.1 shows an adjustable height axle stand used to support the weight of a vehicle.

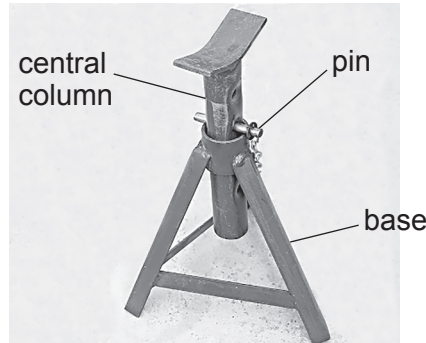


Fig. 1.1

(a) State **three** properties of mild steel that make it suitable for use in the base of the axle stand.

- 1 .....
- 2 .....
- 3 .....

[3]

(b) Describe the type of structure used in the base of the axle stand.

- .....
- .....
- ..... [2]

(c) The pin used to support the central column must resist shear force. Use sketches and notes to describe what is meant by 'shear force'.

[2]

3

- 2 (a) Give **two** reasons why a designer would need to reduce friction in a mechanism.

1 .....

.....

2 .....

.....

[2]

- (b) State **two** methods that can be used to reduce friction in a mechanism.

1 .....

2 .....

[2]

- 3 Products can be designed and manufactured so that they can be disassembled. Describe **two** benefits of being able to disassemble a product after manufacture.

1 .....

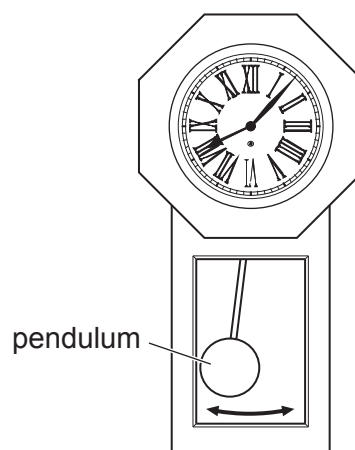
.....

2 .....

.....

[2]

- 4 Fig. 4.1 shows a clock that uses a mechanism to convert motion.



**Fig. 4.1**

- (a) State the type of motion produced by the pendulum.

..... [1]

- (b) State the type of motion produced by the clock hands.

..... [1]

5 Describe, using **one** example, how computers can be used by a manufacturer to increase efficiency in stock control.

.....  
.....  
.....  
..... [3]

6 State the function of an electrical switch.

.....  
..... [1]

7 (a) Name the two types of switch shown in Fig. 7.1.

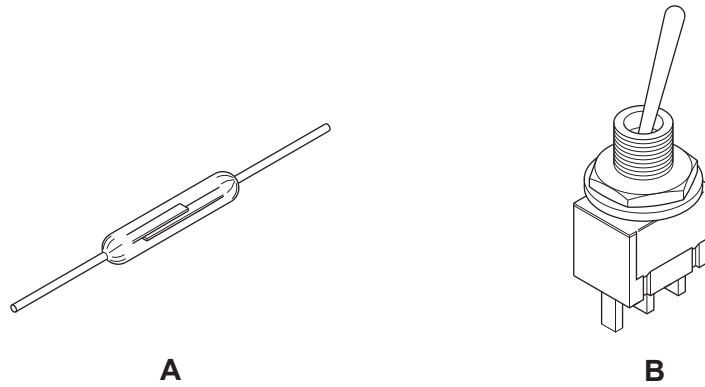


Fig. 7.1

Switch **A** .....

Switch **B** .....

[2]

(b) Describe how switch **A** is operated.

.....  
.....  
..... [2]

8 Fig. 8.1 shows two methods of connecting switches in a circuit.

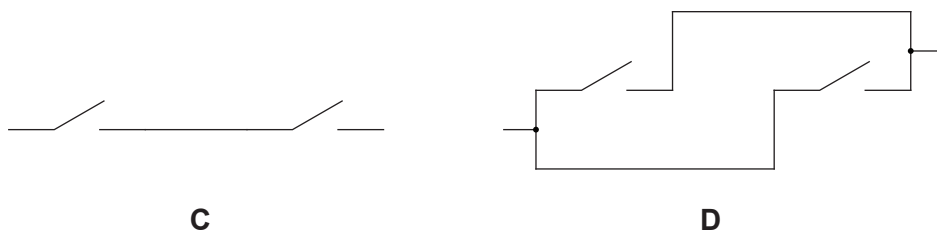


Fig. 8.1

Name each of the methods used.

Method C .....

Method D .....

[2]

**Section B**

Answer **one** question from this section.

9 Fig. 9.1 shows a wooden chair.



**Fig. 9.1**

(a) (i) State **three** forces that may affect the stability of the structure when a person sits on the chair.

1 .....

2 .....

3 .....

[3]

(ii) Fig. 9.2 shows the laminated top rails of the chair.

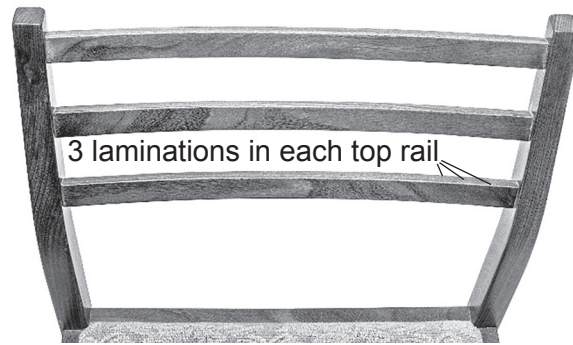


Fig. 9.2

Describe the benefits of using lamination to manufacture the top rails.

.....

.....

.....

.....

..... [3]

(b) Fig. 9.3 shows a joint that could be used in a frame construction.

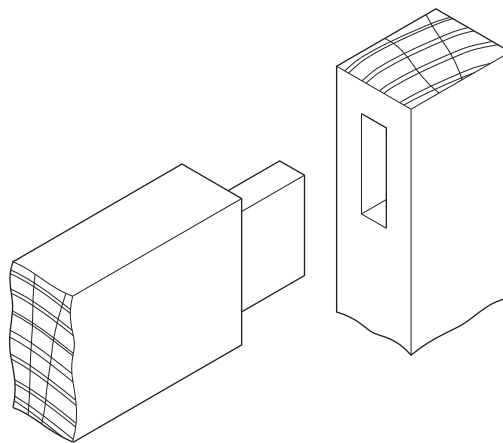


Fig. 9.3

(i) Give **one** benefit of cutting the joint using CAM technology.

.....

..... [1]

(ii) Give **one** benefit of cutting the joint using hand tools.

.....  
..... [1]

(iii) The joint in Fig. 9.3 will be assembled using adhesive.  
State **one** property that the adhesive will need.

..... [1]

(c) (i) Use sketches and notes to describe the differences between the following structural members.

**beam**                      **strut**                      **tie**

[6]

(ii) Suitable materials for structural members must be selected carefully.  
Give **two** examples of defects that should be avoided when selecting wood to be used in structures.

1 .....

2 .....

[2]

(iii) Explain, using an example, how composite materials can be used to improve the performance of a structure.

.....  
.....  
.....  
.....  
..... [3]



(d) Fig. 9.4 shows a workshop hoist with a counterbalance weight.

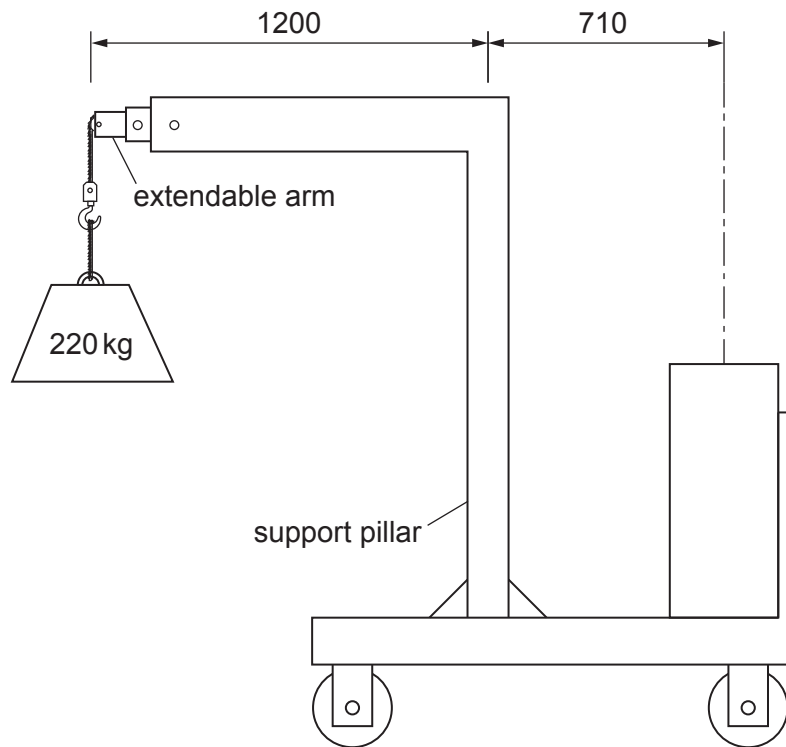


Fig. 9.4

(i) Label the counterbalance weight on Fig. 9.4. [1]

(ii) Calculate the weight of the counterbalance which will keep the workshop hoist structure in equilibrium while lifting the load, with the minimum stress on the structure.

.....

.....

.....

..... [2]

(iii) Describe the considerations that should be taken into account when calculating a Factor of Safety for the workshop hoist.

.....

.....

.....

..... [2]

10 Fig. 10.1 shows three methods of transmitting motion from one shaft to another.

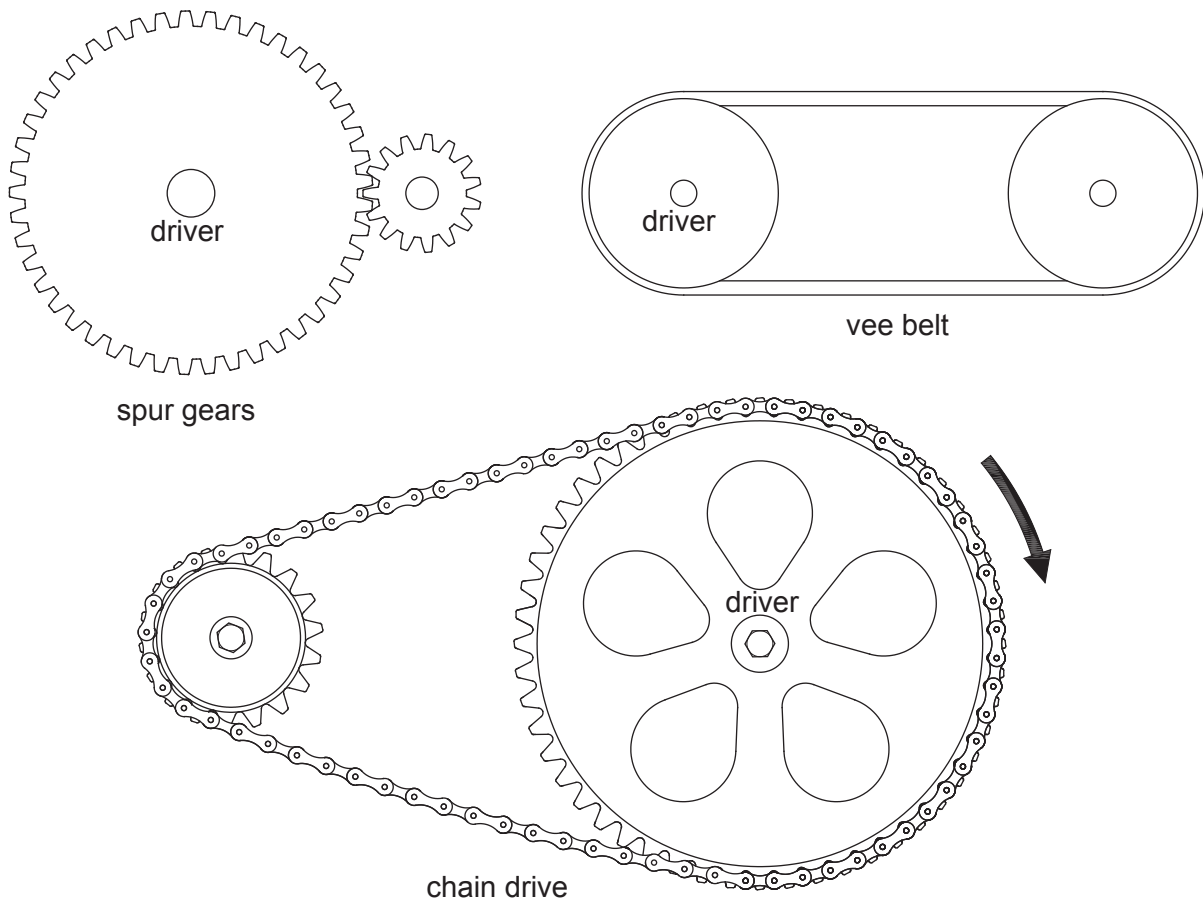


Fig. 10.1

(a) (i) Give **one** different benefit of each method.

spur gears .....

.....

vee belt .....

.....

chain drive .....

.....

[3]

(ii) Circle the area of the chain in Fig. 10.1 that is in tension during rotation in the direction shown. [1]

- (iii) Fig. 10.2 shows a joining link which tightens under tension and is often used to join the ends of a chain together.

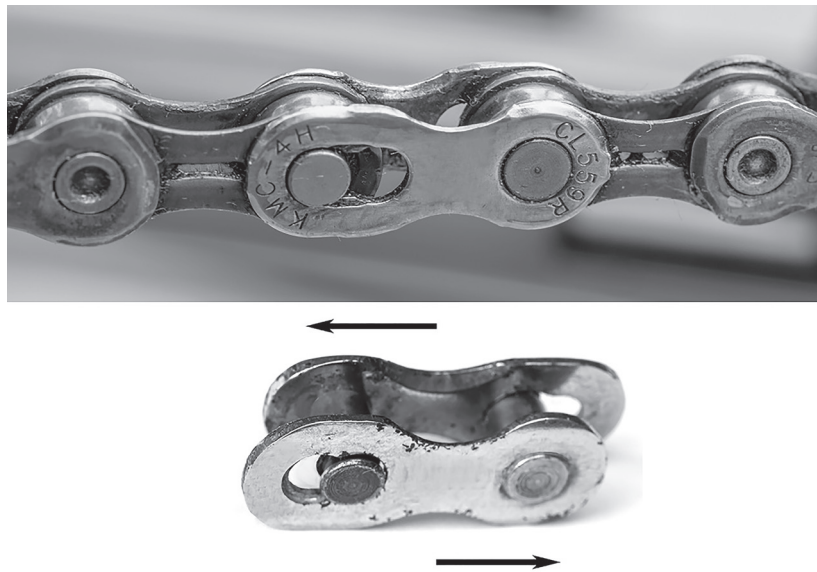
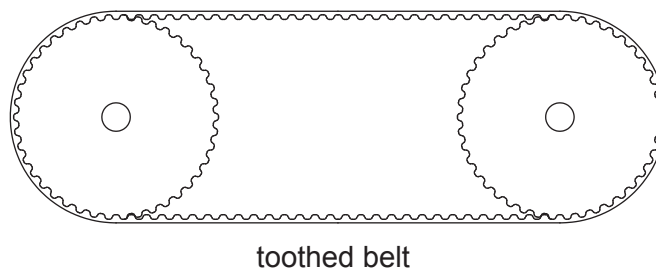


Fig. 10.2

Explain why it is better to use this link as a joining method rather than a rivet.

.....  
.....  
.....  
..... [2]

- (iv) Fig. 10.3 shows a toothed belt drive.



toothed belt

Fig. 10.3

State **one** advantage of a toothed belt compared to a vee belt.

.....  
..... [1]

- (b) Many machine drives use spur gears in the drive train. Use sketches and notes to show a method of adjusting two spur gears to mesh correctly.

[4]

- (c) Fig. 10.4 shows the drive components on a pillar drill.

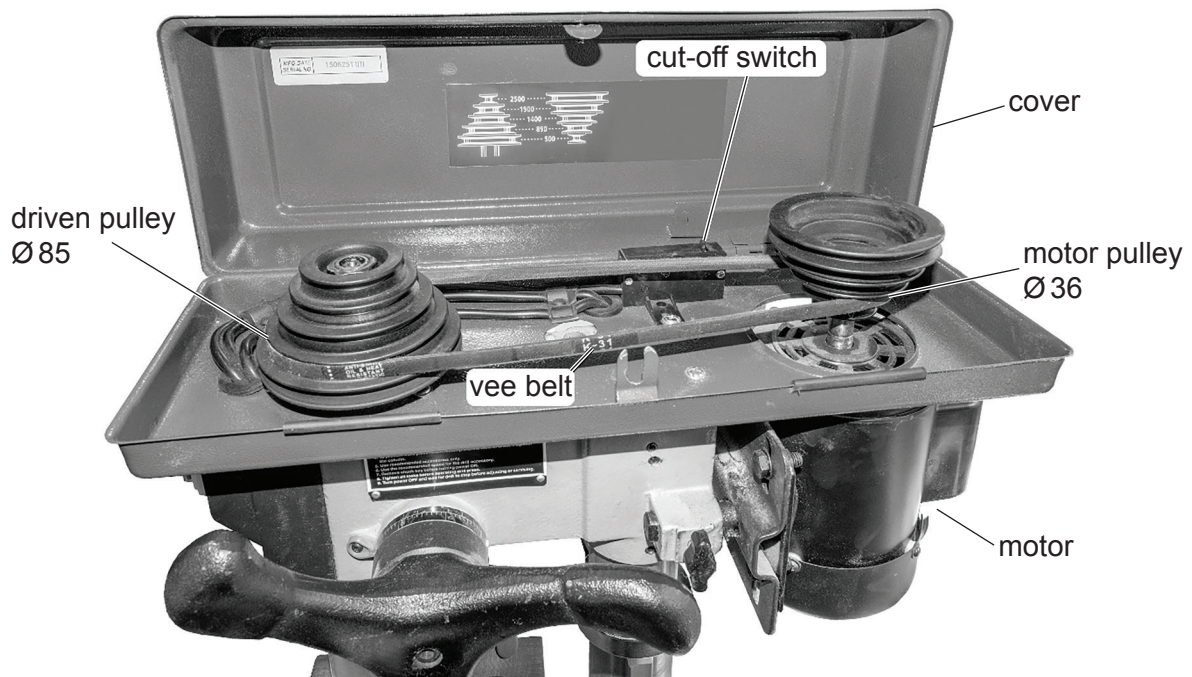


Fig. 10.4

- (i) Give **two** reasons for using a cover over the belt and pulley system.

1 .....

2 .....

[2]

(ii) Calculate the speed of the motor if the driven pulley is rotating at 890 rpm.

.....

.....

.....

..... [3]

(iii) The vee belt is tensioned by using a lever between the motor and pillar before locking it in place as shown in Fig. 10.5.

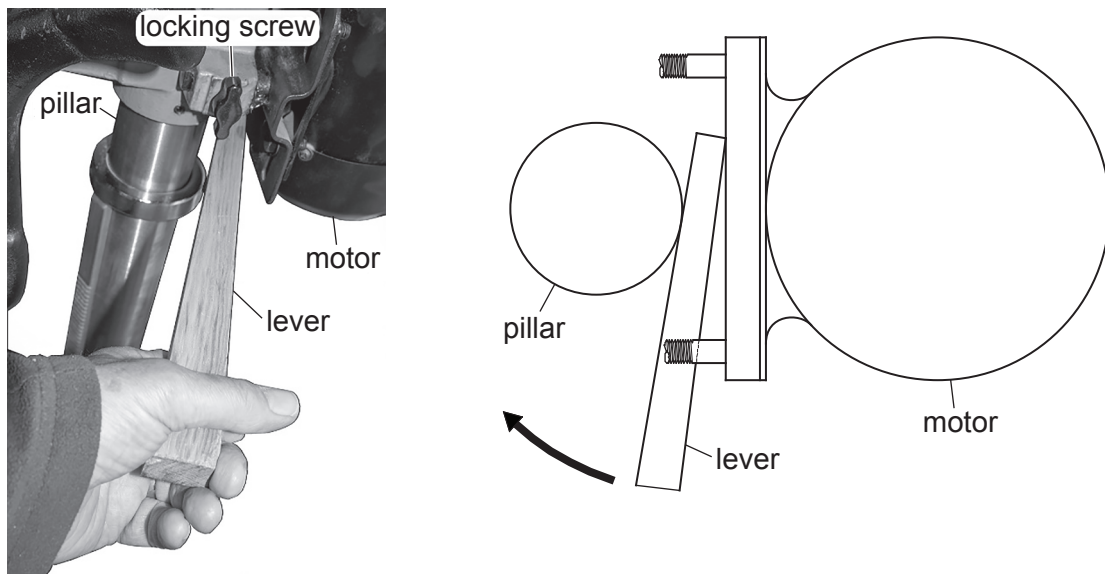


Fig. 10.5

State the order of lever that is used.

..... [1]

(iv) Use sketches and notes to show how the effort applied to the lever, when adjusting the belt, could be reduced.

[2]

(d) Fig. 10.6 shows two gear systems that result in the same reduction of 25:1.

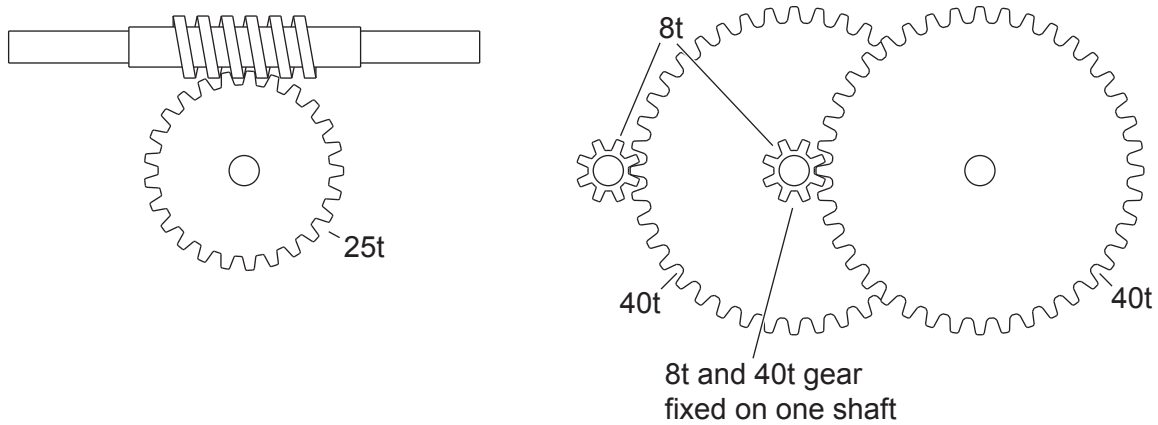


Fig. 10.6

State **two** benefits of using the worm gear arrangement rather than the spur gears.

- 1 .....
- .....
- 2 .....
- .....

[2]

(e) Use the terms given below to complete the methods of converting motion. Each term may be used once, more than once, or not at all.

- rack and pinion**
- cam and follower**
- screw thread**
- crank and slider**
- compound pulley**

Conversion for rotary to linear movement can be carried out using a  
..... or a .....

Conversion from rotary to reciprocating movement can be carried out using a  
..... or a .....

[4]

11 Fig. 11.1 shows a temperature sensing transducer to be used in a controller for a cooling fan.

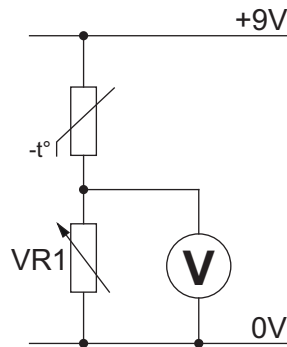


Fig. 11.1

(a) (i) State the name of the temperature sensing transducer.

..... [1]

(ii) Fig. 11.2 shows a potential divider circuit that could be used with the temperature sensing transducer. A table of resistance readings for the transducer is shown.



<b>temperature °C</b>	0	5	10	15	20	25	30
<b>resistance kΩ</b>	17.0	13.2	10.1	8.0	6.3	5.0	4.0

Fig. 11.2

Calculate the voltage that would be displayed on the voltmeter when the temperature reaches 20°C and VR1 is set to 1 kΩ.

Use the formula  $V_{\text{out}} = V_{\text{in}} \times \frac{R_2}{R_1 + R_2}$

.....  
 .....  
 .....  
 ..... [3]

(iii) Explain why the signal from the transducer should **not** be connected directly to a logic system.

.....

.....

..... [2]

(iv) Use sketches and notes to show an additional circuit to that shown in Fig. 11.2 that would make the signal from the transducer suitable for connection to a logic system.

[3]

(b) Fig. 11.3 shows the logic system that is used in the controller.  
The controller has two inputs:

- The temperature sensing circuit which outputs logic 0 when temperature is too high
- A timing clock to set the 'on' period for the controller with a logic 1 signal.

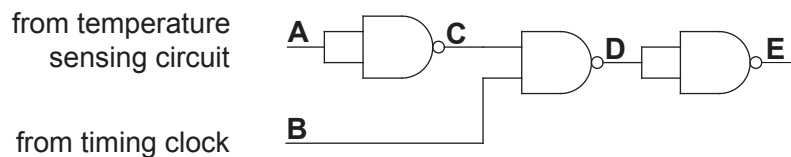


Fig. 11.3

Complete Table 11.1 for the logic system.

Table 11.1

A	B	C	D	E
0	0			
0	1			
1	0			
1	1			

[3]



(c) Fig. 11.4 shows the CMOS IC that will be used in the controller.

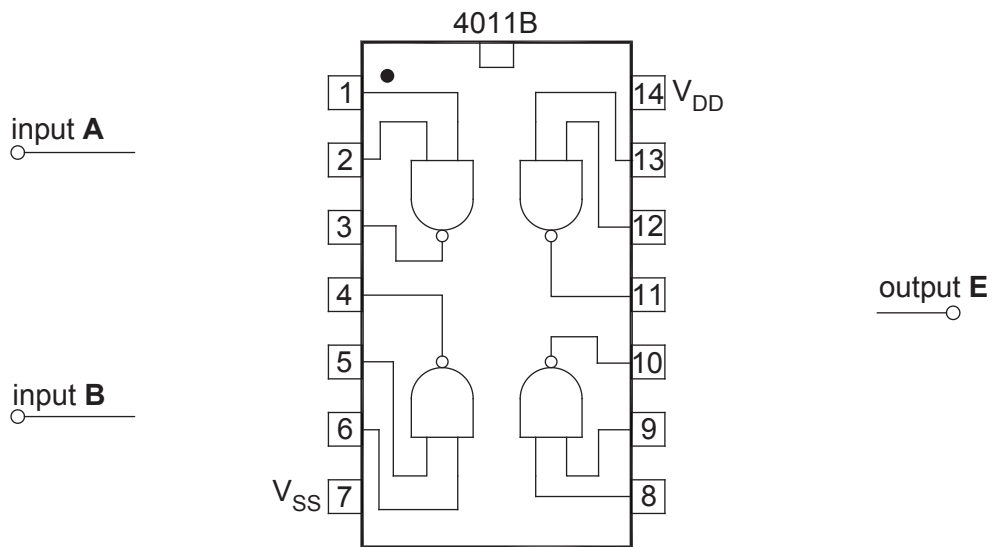


Fig. 11.4

(i) Give a full description of the 4011B IC.

.....  
 .....  
 ..... [2]

(ii) Complete Fig. 11.4 by adding the connections that would make the logic circuit in Fig. 11.3. [3]

(iii) A 10nF capacitor is added to the circuit connected across the supply pins of the logic IC. Explain the reason for adding the capacitor.

.....  
 .....  
 ..... [2]

(d) Fig. 11.5 shows the partly completed output circuit of the cooling fan controller.

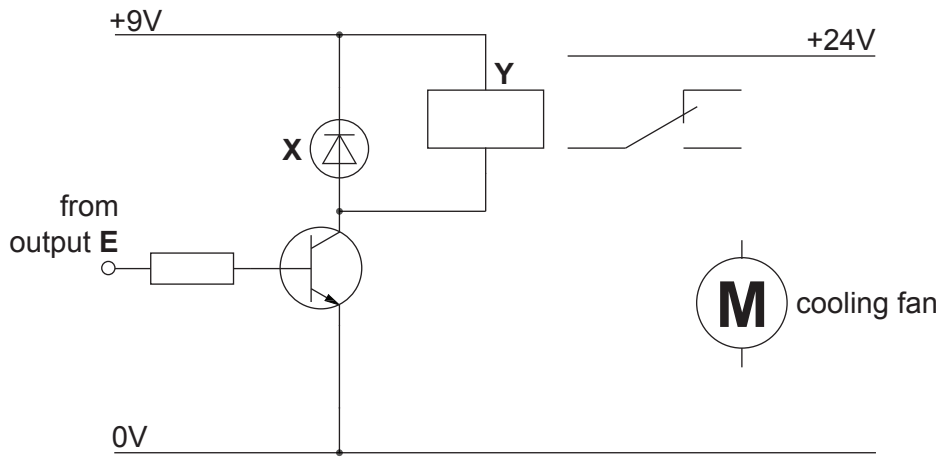


Fig. 11.5

(i) Name components **X** and **Y**.

Component **X** .....

Component **Y** .....

[2]

(ii) Give **two** reasons for using component **Y** in the circuit.

1 .....

.....

2 .....

.....

[2]

(iii) Add the connections on Fig. 11.5 needed to operate the cooling fan.

[2]

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