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## DESIGN & TECHNOLOGY

0445/04

Paper 4 Systems & Control

For examination from 2020

SPECIMEN PAPER

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 [ ].

This document has **20** pages. Blank pages are indicated.

Section A

Answer **all** questions in this section.

1 Fig. 1.1 shows a mechanism used to convert motion.

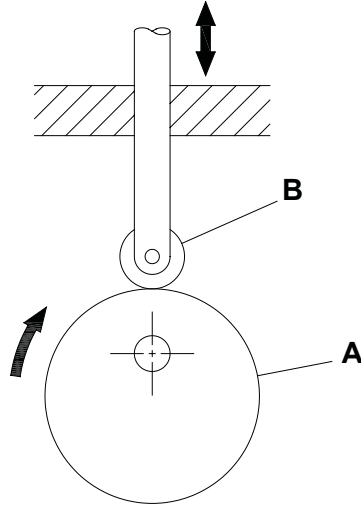


Fig. 1.1

(a) State the conversion of motion that takes place when part **A** rotates.

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

(b) Give **one** reason for using roller **B**.

..... [1]

2 Fig. 2.1 shows a wheelbarrow.

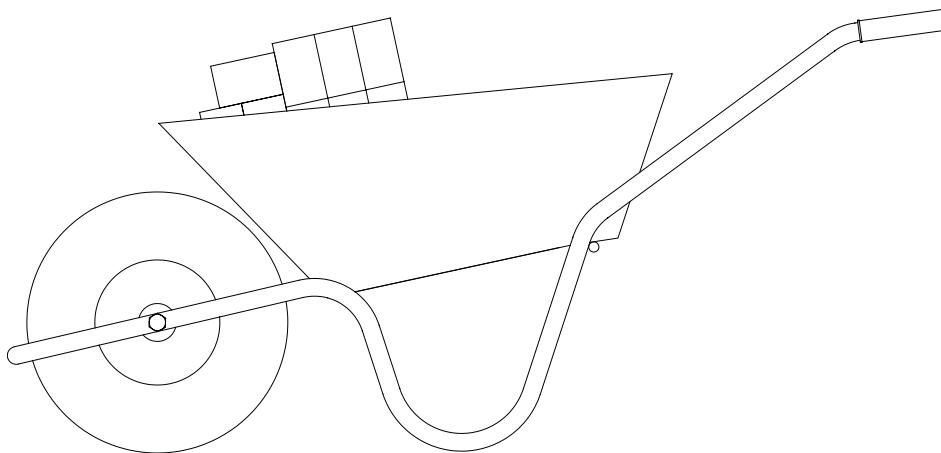


Fig. 2.1

Add labels to show the positions of effort, load and fulcrum.

[3]

- 3 Use sketches and notes to show **one** method of linking two shafts together so that they will rotate in opposite directions.

[3]

- 4 Fig. 4.1 shows a brick wall with a crack in it.

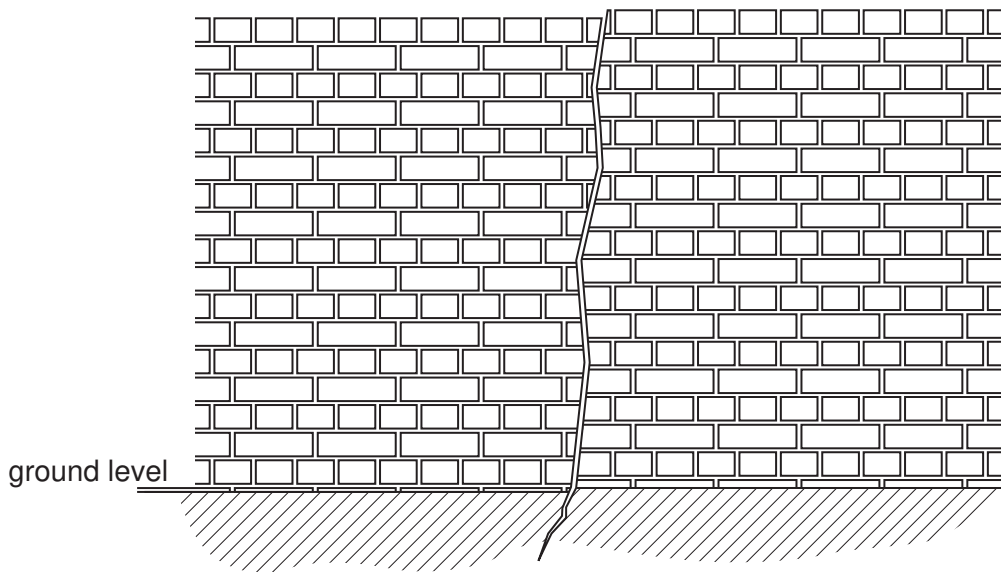


Fig. 4.1

- (a) State the force that has caused the crack.

..... [1]

- (b) Give **one** possible reason why the crack has occurred.

..... [1]

5 Fig. 5.1 shows the support frame for a shelf unit attached to a wall using screws.

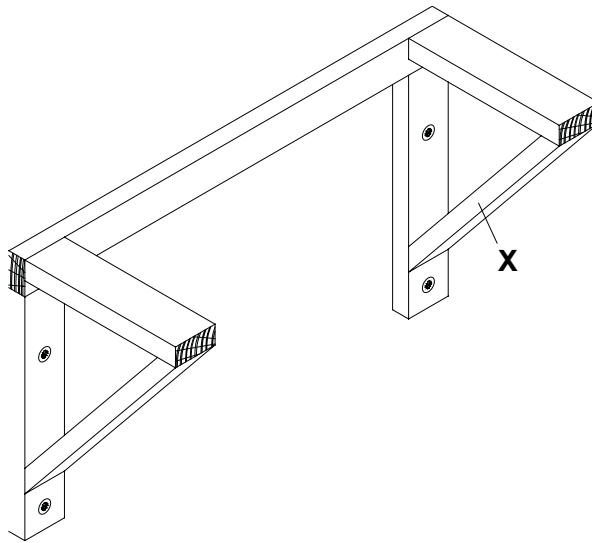


Fig. 5.1

(a) State the force that will act on each screw as it is being inserted with a screwdriver.

..... [1]

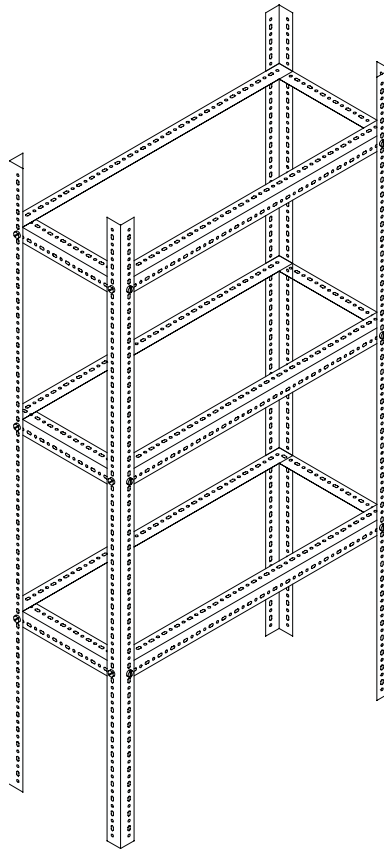
(b) State the force that will act on part X when the shelf unit is loaded.

..... [1]

(c) Explain how the designer is responsible for the safety of the support frame.

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

- 6 Fig. 6.1 shows the framework for a set of shelves used to carry heavy loads in a workshop. The frame is made from slotted steel angle material that is bolted together.



**Fig. 6.1**

- (a) Draw on Fig. 6.1 to show how triangulation can be used to make the framework more rigid when the shelves are loaded. [2]

- (b) Describe what is meant by the static load of the set of shelves.

.....

.....

..... [2]

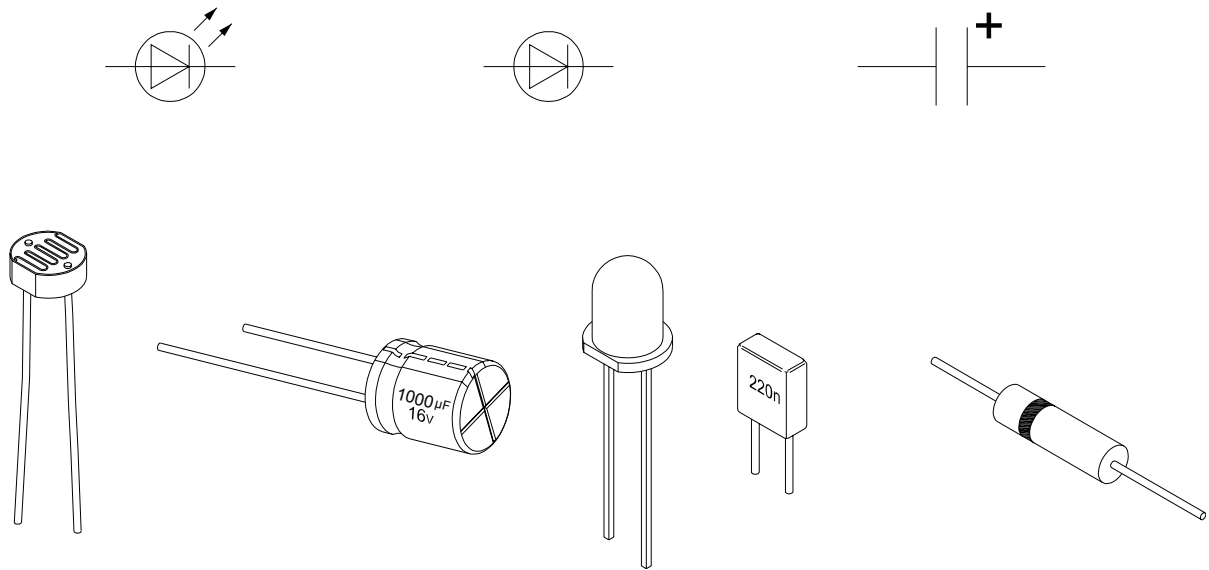
- 7 Fig. 7.1 shows a microswitch and the symbol for the microswitch. Draw lines to connect the wires to the switch to allow it to be used as a push to break switch.



**Fig. 7.1**

[2]

8 Fig. 8.1 shows three circuit symbols and drawings of five electronic components.



**Fig. 8.1**

Draw a line from each circuit symbol to the electronic component that matches the symbol. [3]

9 Name the unit used to measure electrical current.

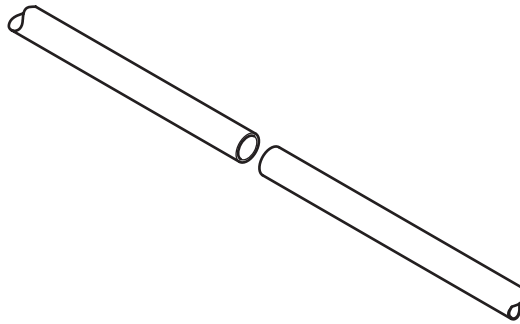
..... [1]

## Section B

Answer **one** question from this section.

**10** Materials used in structures often have to be joined to extend the length of the material.

- (a) Fig. 10.1 shows two steel tubes that need to be joined end to end to extend the length of the tube. End to end welding cannot be used.  
Draw on Fig. 10.1 to show how the steel tubes can be joined so that they are in line and the joint will resist bending.



**Fig. 10.1**

[3]

- (b) Fig. 10.2 shows the wings of a biplane.



**Fig. 10.2**

- (i) Add labels to Fig. 10.2 to identify a strut and a tie.

[2]

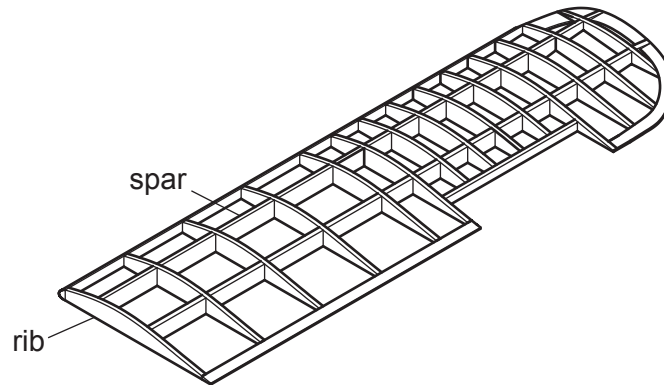
(ii) Name the force resisted by a strut.

..... [1]

(iii) Name the force resisted by a tie.

..... [1]

(iv) The wings of the biplane are made from ribs and spars as shown in Fig. 10.3.

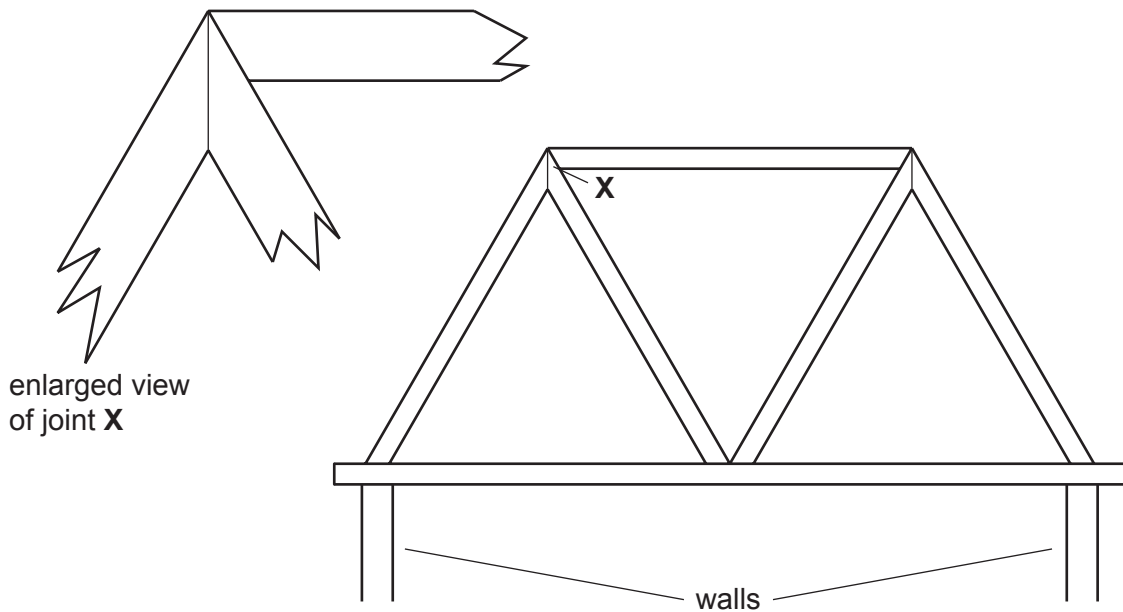


**Fig. 10.3**

State the name for this type of structure.

..... [1]

(c) Fig. 10.4 shows a roof truss resting in equilibrium on two walls.



**Fig. 10.4**

(i) Draw a gusset plate on the enlarged view of joint X shown in Fig. 10.4. Show how the gusset plate will be fixed in position.

[3]



(ii) Describe what is meant by equilibrium in a structure.

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

(d) Fig. 10.5 shows two wooden floor beams, X and Y. Beam X is placed on its wide edge. Beam Y is placed on its narrow edge.

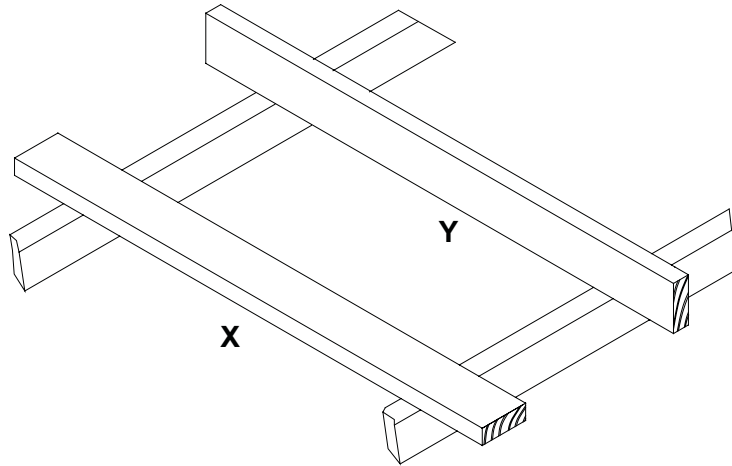


Fig. 10.5

(i) Explain why floor beams should be placed as shown for beam Y.

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

(ii) Give **three** things to consider other than natural defects in materials when applying a factor of safety in structural design.

1 .....

.....

2 .....

.....

3 .....

..... [3]

(iii) Describe **two** defects in a length of wood that should be avoided when selecting the wood for use in a structure.

1 .....

2 .....

[2]

(e) Fig. 10.6 shows part of a ladder made from hollow aluminium sections.

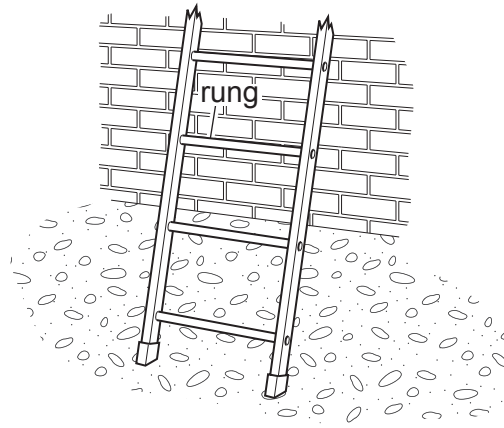


Fig. 10.6

(i) Give **two** manufacturing advantages of using aluminium rather than wood for the construction of a ladder.

1 .....

2 .....

[2]

(ii) Fig. 10.7 shows the position of the foot of a user on the bottom rung of the ladder.

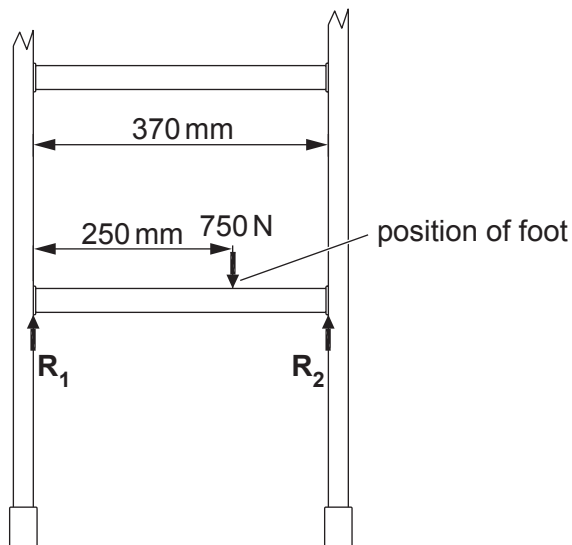


Fig 10.7

Calculate the reactions  $R_1$  and  $R_2$ .

.....  
 .....  
 .....  
 .....

[3]

11 A gear system is shown in Fig. 11.1. The direction of rotation of gear **A** is shown by an arrow.

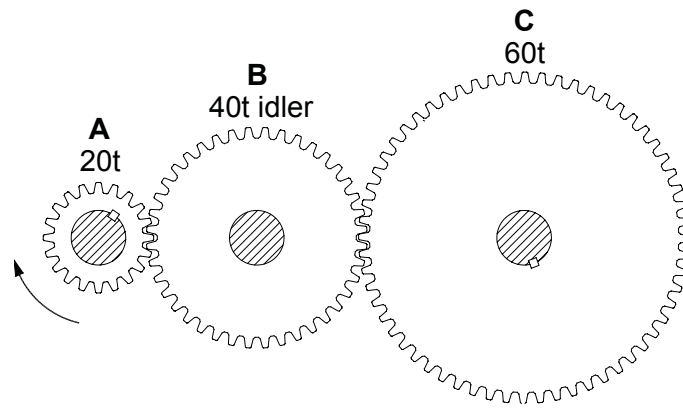


Fig. 11.1

(a) (i) Add arrows to Fig. 11.1 to show the direction of rotation of gears **B** and **C**. [2]

(ii) Gear **A** rotates at 60 rpm.  
Calculate the speed of rotation of gear **C**.

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

(iii) Gears **A** and **C** are fixed to their shafts with a key.  
Explain why gear **B** does not need to be fixed to the shaft.

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

(b) Two different bearing types are shown in Fig. 11.2.

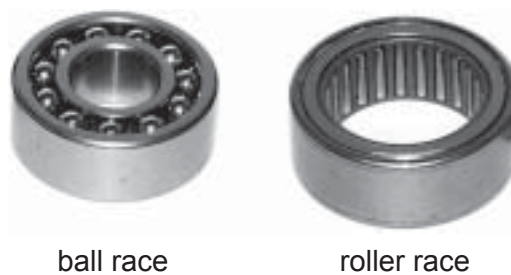


Fig. 11.2

Give **one** benefit of each type of bearing.

Benefit of ball race .....  
 .....

Benefit of roller race .....  
 .....

(c) Fig. 11.3 shows the winding mechanism for a lift (elevator).

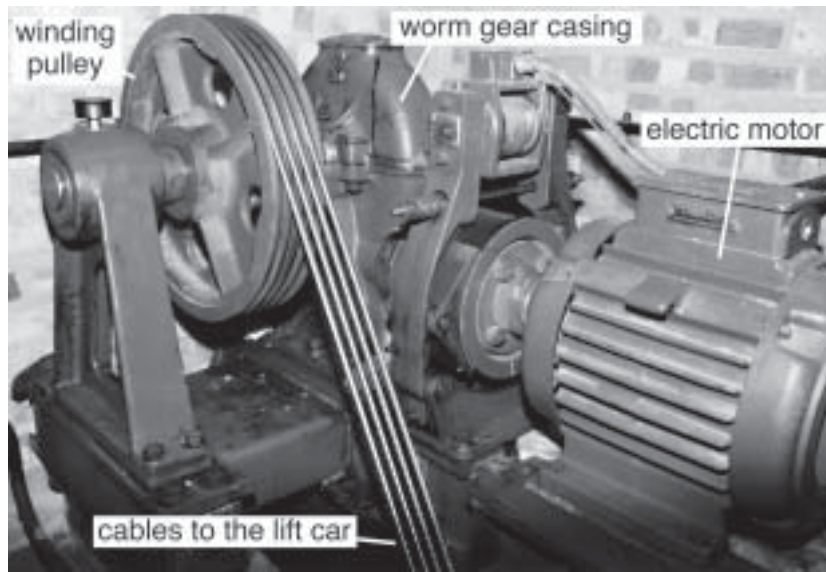


Fig. 11.3

(i) The motor is connected to the winding pulley by a worm gear. Explain why a worm gear is suitable for this application.

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

(ii) The winding pulley uses four cables connected to the lift car. Give **one** reason for using four cables.

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

(d) Fig. 11.4 shows an electric motor connected to a compressor by a vee belt.

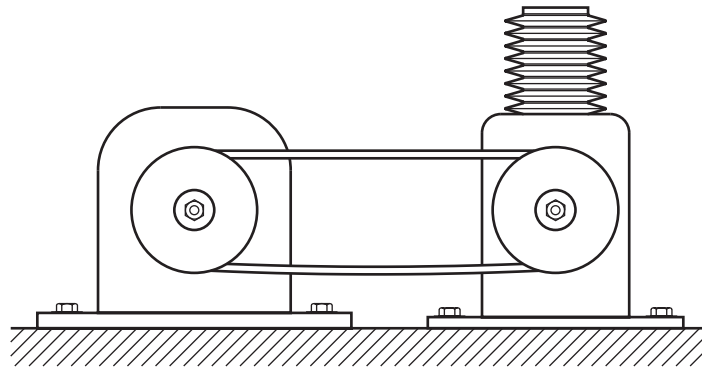


Fig. 11.4

- (i) Give **one** benefit of using a vee belt.  
..... [1]
- (ii) Name **one** other type of belt that could be used.  
..... [1]
- (iii) Use sketches and notes to show **one** method of adjusting the tension on the vee belt.

(e) A cam and lever follower which are part of a mechanical toy are shown in Fig. 11.5.

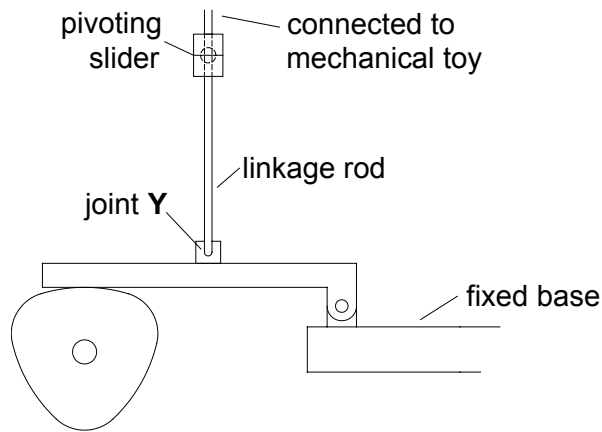


Fig. 11.5

(i) Add labels to Fig. 11.15 to show the position of the load, effort and fulcrum on the lever follower. [3]

(ii) State the order of lever used in the follower.

..... [1]

(iii) Describe the action of the lever follower for one rotation of the camshaft.

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

(iv) Give the reason that joint Y is not a rigid joint.

..... [1]

12 (a) State the meaning of the circuit symbols shown in Fig. 12.1.

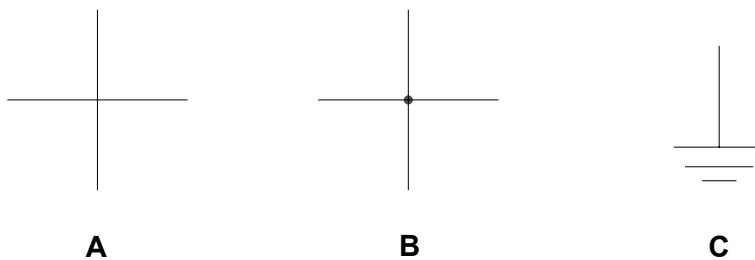


Fig. 12.1

- A .....
- B .....
- C .....

[3]

(b) LEDs of different colours are commonly used in electronic circuits. State **two** other ways in which LEDs can differ.

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

[2]

(c) The list below gives component values available for a time delay circuit.

capacitor				
100 nF	2200 pF	470 $\mu$ F	100 $\mu$ F	330 nF

resistor				
100 $\Omega$	2 M $\Omega$	270 k $\Omega$	6.8 $\Omega$	1.5 k $\Omega$

State the values of the **two** components that will give the longest delay.

Capacitor value .....

Resistor value .....

[2]

- (d) Fig. 12.2 shows an operational amplifier symbol and the pin diagram of an operational amplifier IC. The circuit will operate on a 6V single rail supply.

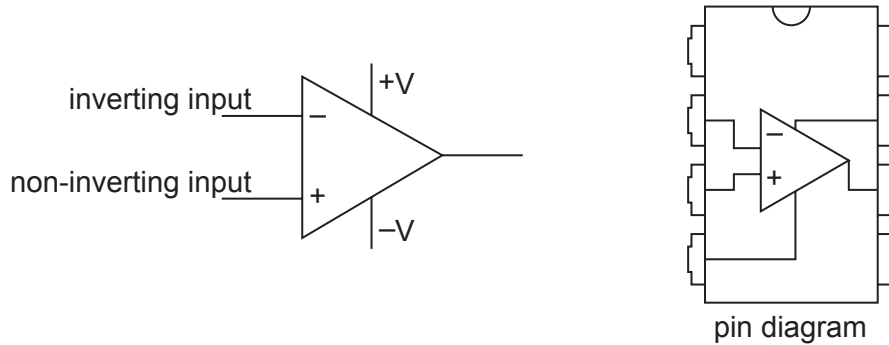


Fig. 12.2

- (i) Use information from the IC pin diagram to add pin numbers to the power connections on the operational amplifier symbol. [2]
- (ii) Complete the table below to show the approximate output voltage of the operational amplifier for the given input conditions.

Input condition	Approximate output voltage
inverting input > non-inverting input	
non-inverting input > inverting input	

[2]

- (e) A toy car can be made to reverse when a push to make switch, **SW1** is pressed. The circuit is shown in Fig. 12.3.

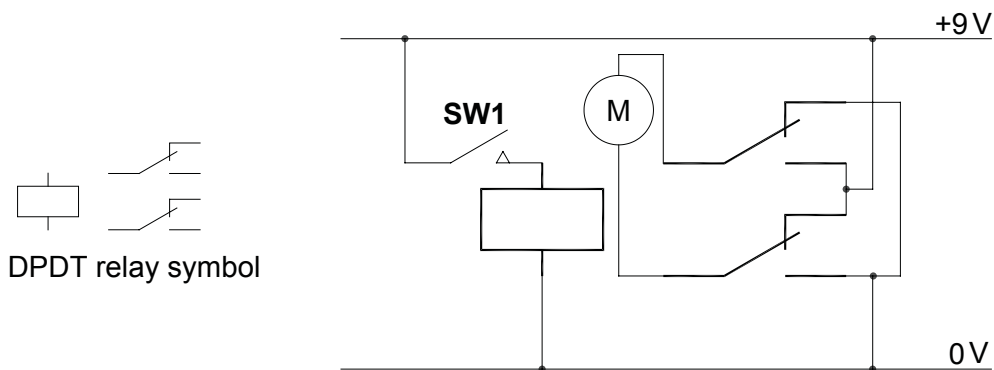


Fig. 12.3



Describe how the circuit in Fig. 12.3 causes the motor to change direction.

.....

.....

.....

..... [2]

- (f) In a quiz competition the first player to press their switch can answer the question. Fig. 12.4 shows a logic circuit that can detect which switch has been pressed first.

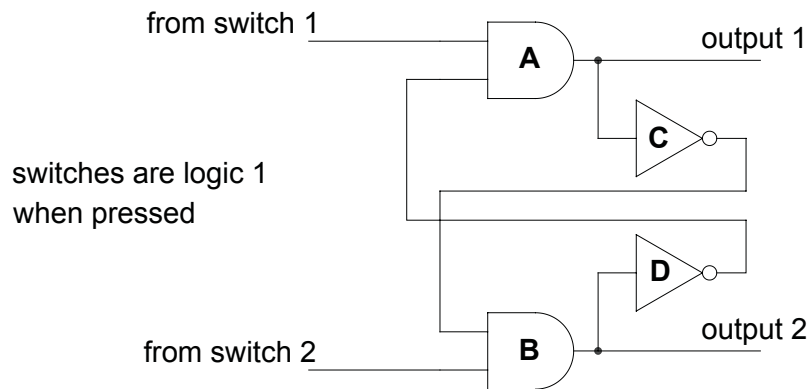


Fig. 12.4

- (i) State the names of the **two** types of logic gate used in the circuit.

1 ..... 2 ..... [2]

- (ii) Explain why output 2 cannot be at logic 1 when switch 1 has been pressed first.

.....

.....

..... [2]

- (iii) To show which player pressed their switch first, a light is connected to each output. Complete the connections on the light switching circuit in Fig. 12.5.

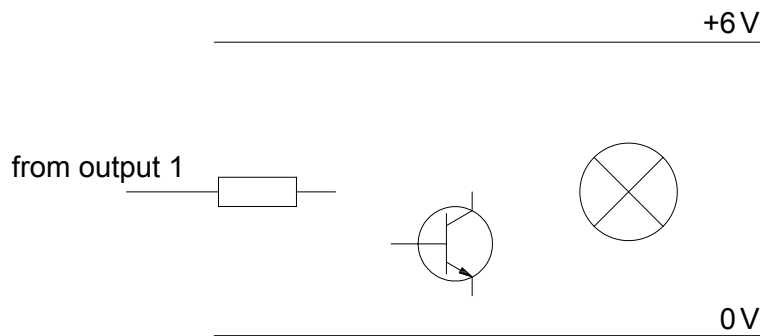


Fig. 12.5

[3]

- (g) Fig. 12.6 shows the outputs of a 4026 CMOS counter IC connected to a 7 segment display. Each output is connected through a resistor to a segment of the display.

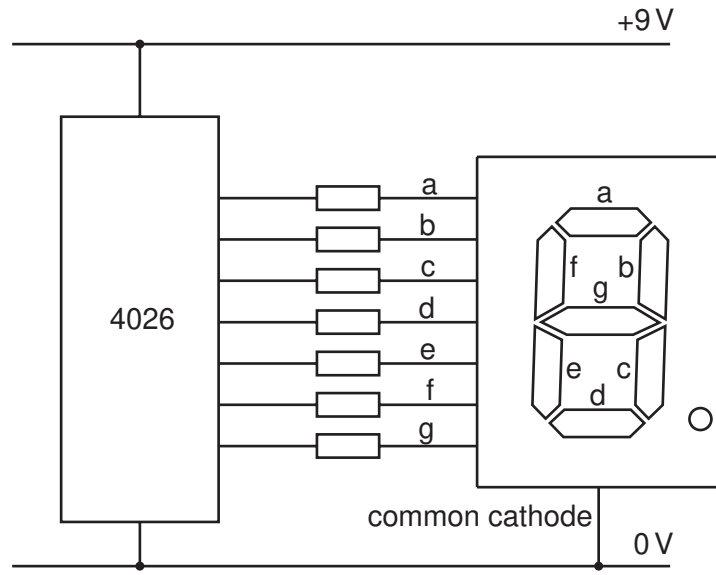


Fig. 12.6

- (i) Calculate the value of resistor needed to limit the current in each segment to 15 mA. There is a voltage drop of 2V on each segment of the display.

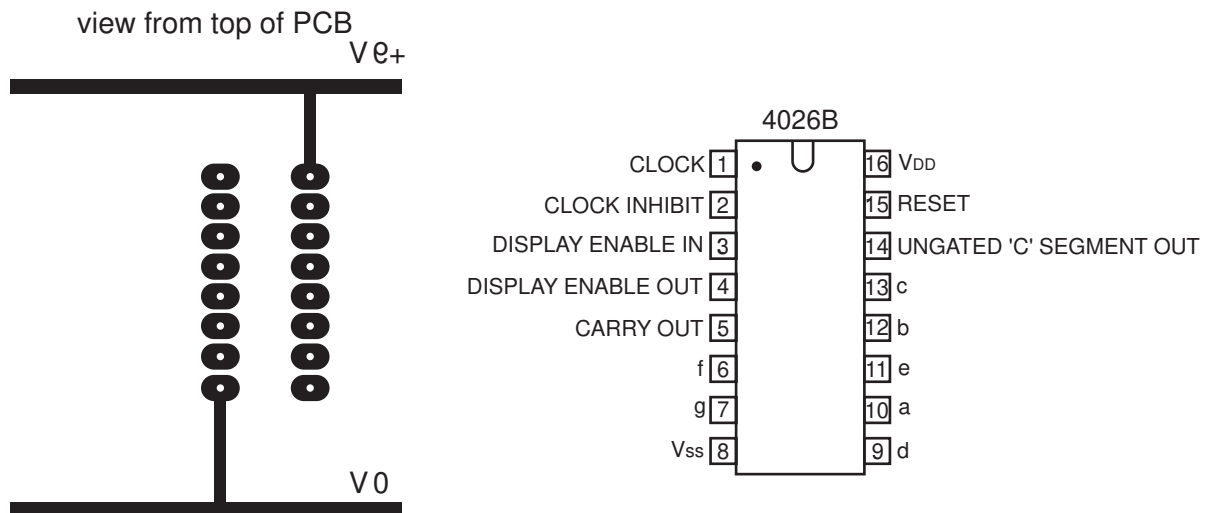
Use the formula  $V = I \times R$

.....

.....

..... [3]

(ii) Fig. 12.7 shows part of the printed circuit layout and the pin diagram for the 4026 IC.



**Fig. 12.7**

Add tracks to make the following connections:

- DISPLAY ENABLE IN (pin 3) to +9V
- CLOCK INHIBIT (pin 2) to 0V.

[2]

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