CANDIDATE NAME
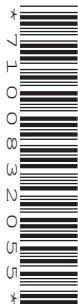
CENTRE NUMBER

CANDIDATE NUMBER

DESIGN AND TECHNOLOGY 0445/41

Paper 4 Systems and Control **October/November 2017**

1 hour

Candidates answer on the Question Paper.

No Additional Materials are required.

READ THESE INSTRUCTIONS FIRST

Write your Centre number, candidate number and name on all the work you hand in.
Write in dark blue or black pen.
You may use an HB pencil for any diagrams or graphs.
Do not use staples, paper clips, glue or correction fluid.
DO **NOT** WRITE IN ANY BARCODES.

Section A
Answer **all** questions in this section.

Section B
Answer **one** question in this section.

You may use a calculator.

At the end of the examination, fasten all your work securely together.
The number of marks is given in brackets [ ] at the end of each question or part question.
The total of the marks for this paper is 50.

This document consists of **17** printed pages and **3** blank pages.

Section A

Answer **all** questions in this section.

1   (a)   Fig. 1 shows three switches and their circuit symbols.
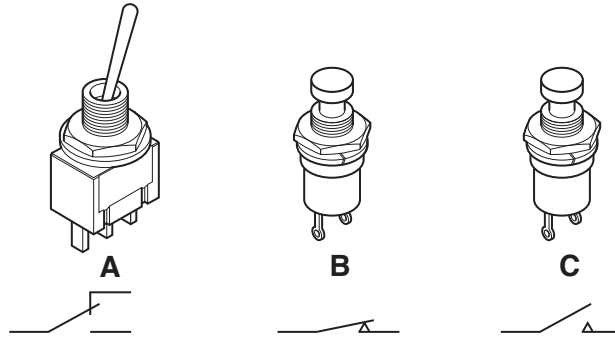
Fig. 1

Use the information in Fig. 1 to complete the table below.

	Type	Action	Contact arrangement
Switch **A**		on / off / on	SPDT
Switch **B**	push switch		SPST
Switch **C**	push switch	PTM	

[3]

(b)   (Circle) the number of connections that a double pole double throw (DPDT) switch will have.

1   3   4   6   8   [1]

2   Fig. 2 shows an LED, a resistor and an ammeter in a circuit.

Fig. 2

Complete the circuit to show the ammeter connected to measure the current flow when the LED is lit.   [3]

3 A transistor can be used as an electronic switch.
Give **two** advantages of a transistor switch over a mechanical switch such as a push switch.

1 ....

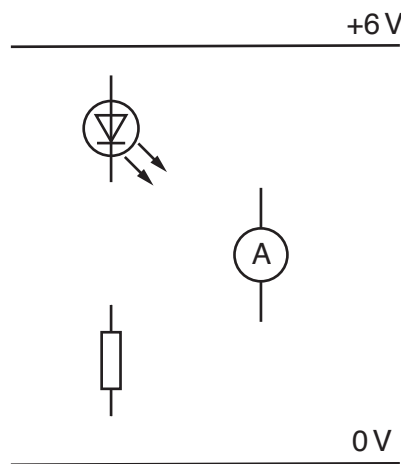2 ....

[2]

4 Fig. 3 shows an ice cream scoop that uses a moveable bar to release a ball of ice cream when the lever is pressed. The lever operates a gear linked to the moveable bar.
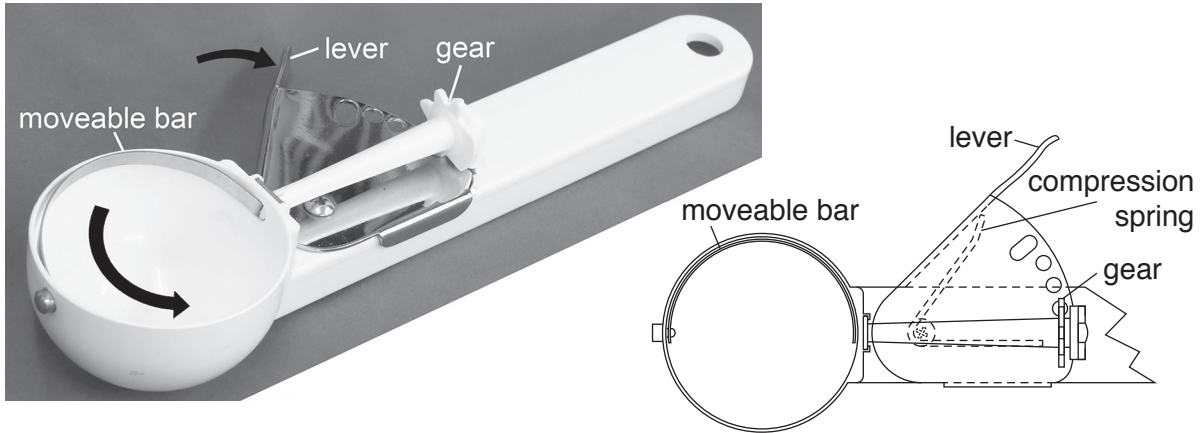
Fig. 3

(a) State the conversion of motion that takes place when the lever is pressed.

.... motion in the lever is converted to .... motion in the moveable bar. [2]

(b) State the order of lever used in the ice cream scoop.

....[1]

(c) Describe how the movement of the lever is transferred to the moveable bar.

....

....

....[2]

5 Draw an example of a third order lever and label the position of the fulcrum, load and effort.

[4]

6 Draw and name a natural frame structure.

[1]

7 Draw and name a natural shell structure.

[1]

8 Fig. 4 shows a bracket made from square steel tube.
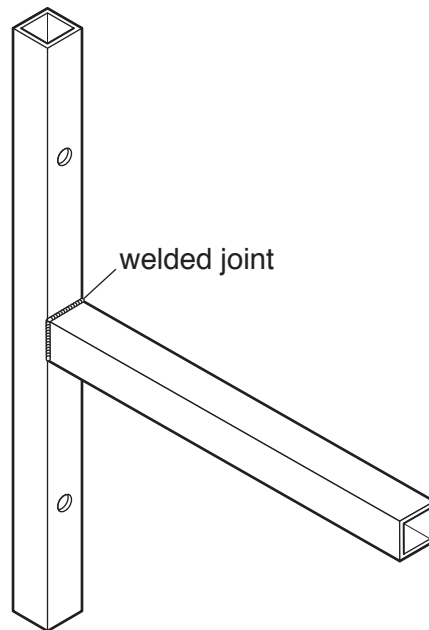
Fig. 4

Use sketches and notes on Fig. 4 to show a method of reinforcing the welded joint in the bracket.
[3]

9 Describe what is meant by equilibrium in a structure.

....

....

....[2]

Section B

Answer **one** question in this section.

10 Fig. 5 shows a roof truss.

Fig. 5

(a) Use the terms given below and information from Fig. 5 to complete the description.

torsion   compression   tension   bending   A   B

Part .... is a strut, which is placed there to resist ....

Part .... is a tie which will resist ....

When the roof covering is added, part **C** will have to resist a .... force.   [5]

(b) Explain the meaning of the following terms that appear on a stress / strain graph for mild steel.

(i) Elastic deformation ....

....

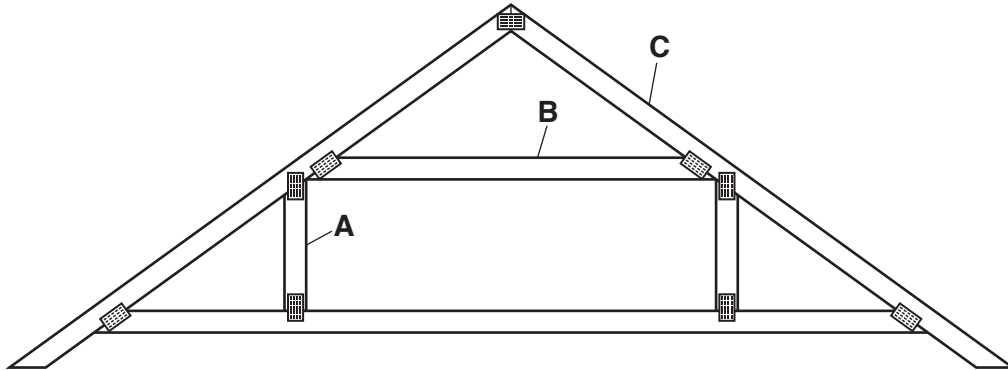..[2]

(ii) Elastic limit ....

....

....[2]

(iii) Plastic deformation ....

....

....[2]

(c) Fig. 6 shows a flagpole made from aluminium tube.
The flagpole can be rotated about a pivot for maintenance of the pulley at the top.
The raised flagpole is held in position by a locking pin.
Cables are used to stabilise the raised flagpole in high winds.
One cable is shown in position.
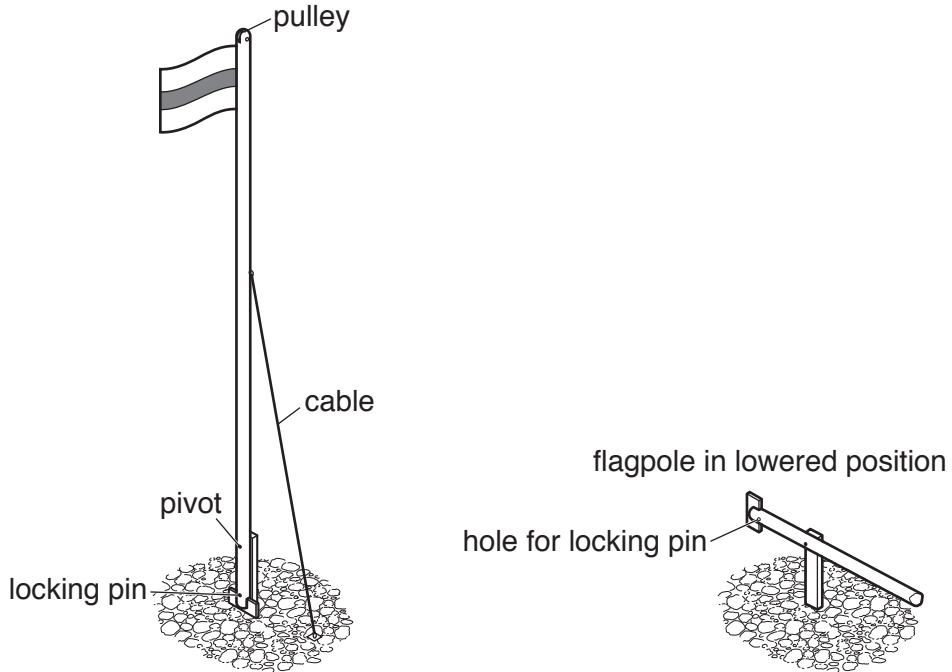
Fig. 6

(i) State the **minimum** number of cables that should be used to stabilise the flagpole.

....[1]

(ii) Use sketches and notes to show a method of tensioning the cables that allows for adjustment.

[3]

(iii) State the force that will be applied to the pivot when the flagpole is raised and the cables are tight.

....[1]

(iv) Fig. 7 shows the flagpole in the raised and lowered positions.
To lower the flagpole the locking pin is removed and the flagpole rotates about the pivot.

5.1 m

flagpole

pivot

0.9 m

locking pin
counterweight

X 25 N   125 N

0.45 m
0.45 m   2.55 m   2.55 m
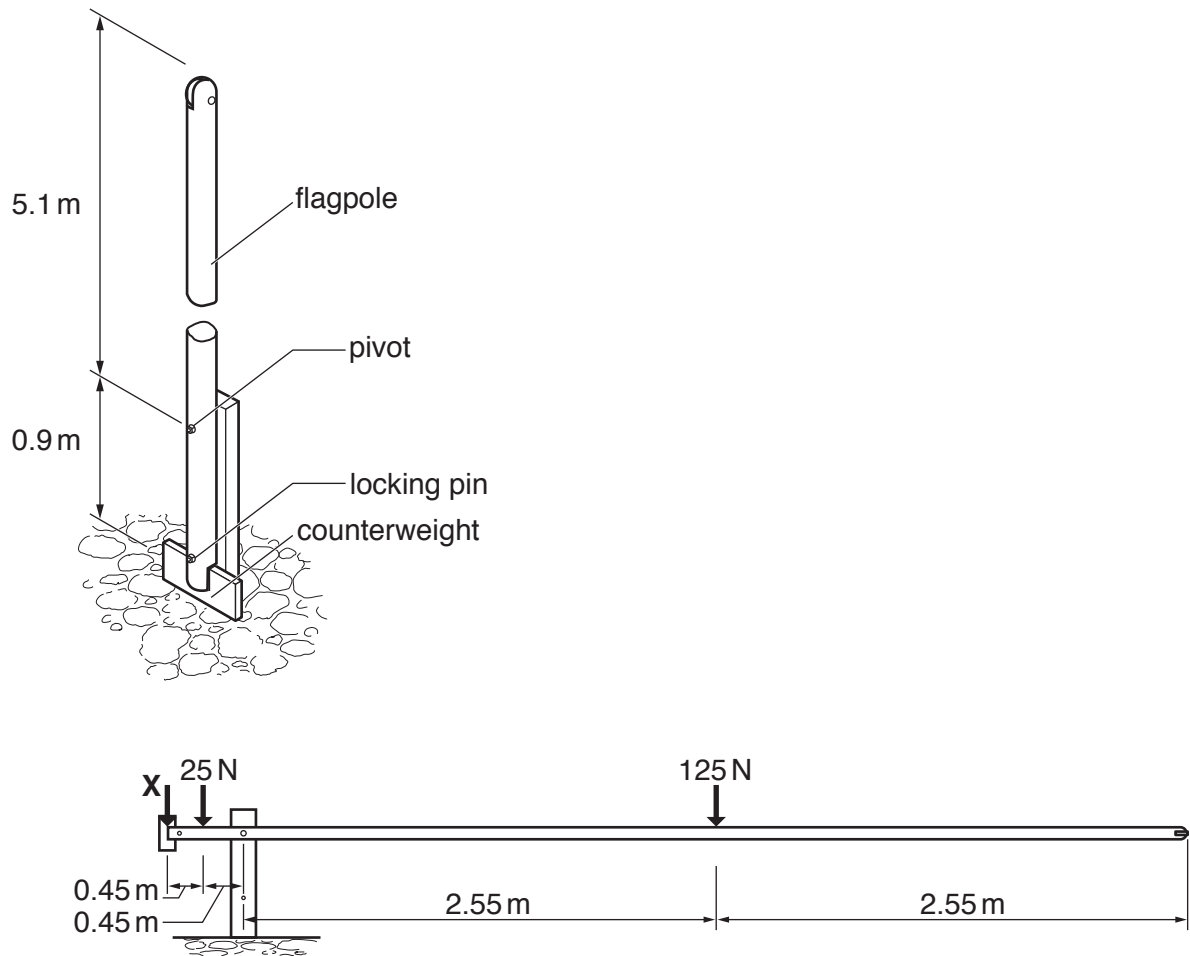
Fig. 7

The 25 N and 125 N forces represent the distributed load of the aluminium tube.
Calculate the value of counterweight **X** that will be required to keep the pole in equilibrium.

....

....

....

....

....[4]

(d) Fig. 8 shows a truss bridge.

Fig. 8

Describe, using examples, the difference between static (stationary) loads and dynamic (moving) loads on the structure of the bridge.

....

....

....

....

....

....[4]

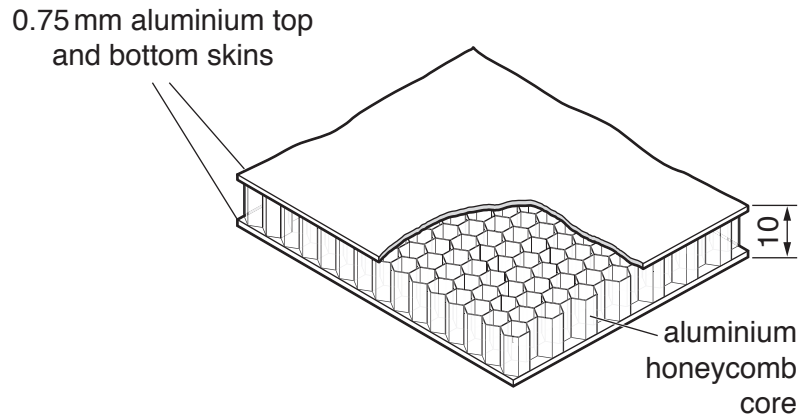**(e)** Fig. 9 shows a piece of aluminium honeycomb sheet of the type commonly used in aircraft manufacture.

0.75 mm aluminium top and bottom skins

10

aluminium honeycomb core

Fig. 9

Give **one** reason why this material is suitable for aircraft manufacture.

....

....[1]

11 Power sources used to operate mechanisms usually have safety features that will prevent injury to a user.

(a) Complete the table using a suitable safety device for each power source from the list given below. One has been done for you.

PTM switch   **solenoid valve**   **fuse**

residual current device (RCD)   **regulator**

Power Source	Safety Device
mains electricity	
natural gas	
low voltage electricity	fuse
compressed air	

[3]

(b) Two types of drive system are shown in Fig. 10.

driver

belt drive

40 t   10 t   60 t
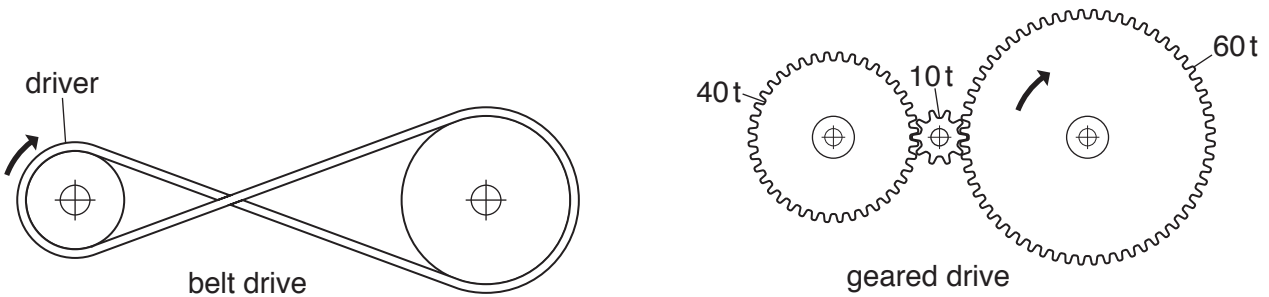
geared drive

Fig. 10

(i) Describe **two** outcomes of using the belt drive system shown in Fig. 10.

1 ....

2 ....
[2]

(ii) Draw on Fig. 10 to show the direction of rotation of the 10 t gear and the 40 t gear in the geared drive system. [2]

(iii) Give **two** benefits of using a belt drive rather than a geared drive.

1 ....

2 ....
[2]

(iv) Explain why drive systems cannot be 100% efficient.

....

....

....

....[3]

(c) Fig. 11 shows a hand drill.
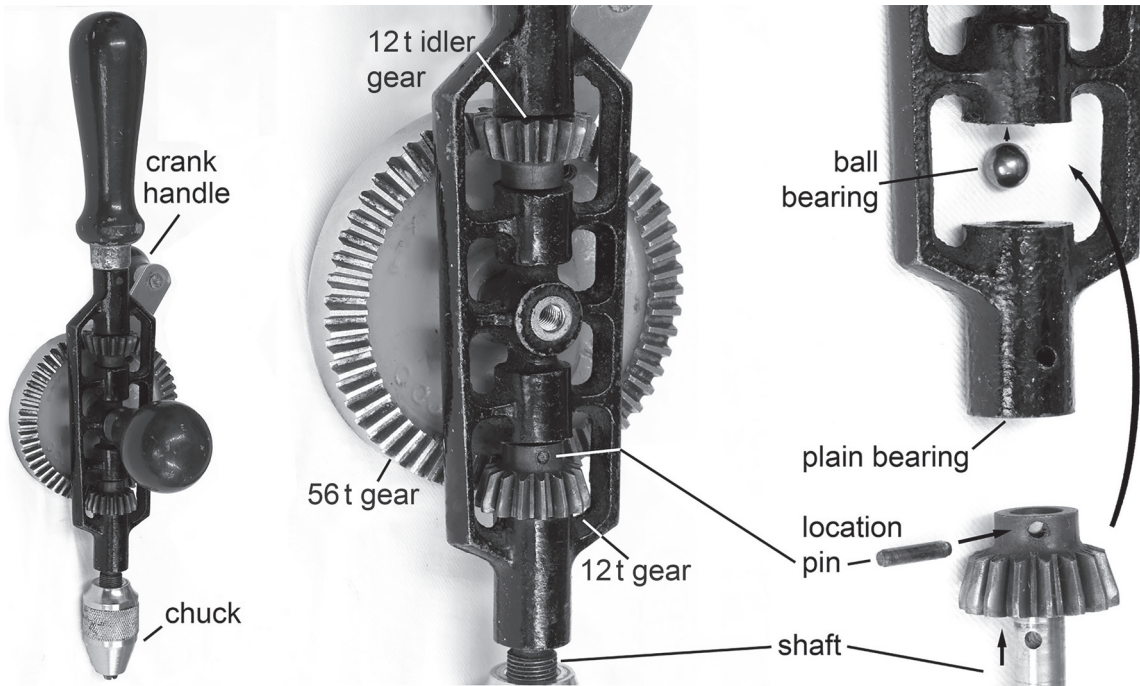
Fig. 11

(i) Name the type of gear used in the hand drill.

....[1]

(ii) Give **two** reasons for using this type of gear in the hand drill.

1 ....

2 ....
                                                                                                                    [2]

(iii) State the velocity ratio of the gears used in the hand drill.

....[2]

(iv) Calculate the speed of the chuck when the handle turns the 56t gear at 60 rpm.

....

....

....[2]

(v) The shaft of the hand drill rotates in plain bearings.
Give **one** drawback of using plain bearings.

....[1]

(vi) The end of the shaft rotates against a ball bearing.
Explain why the ball bearing is needed in this position.

....

....

....

....[2]

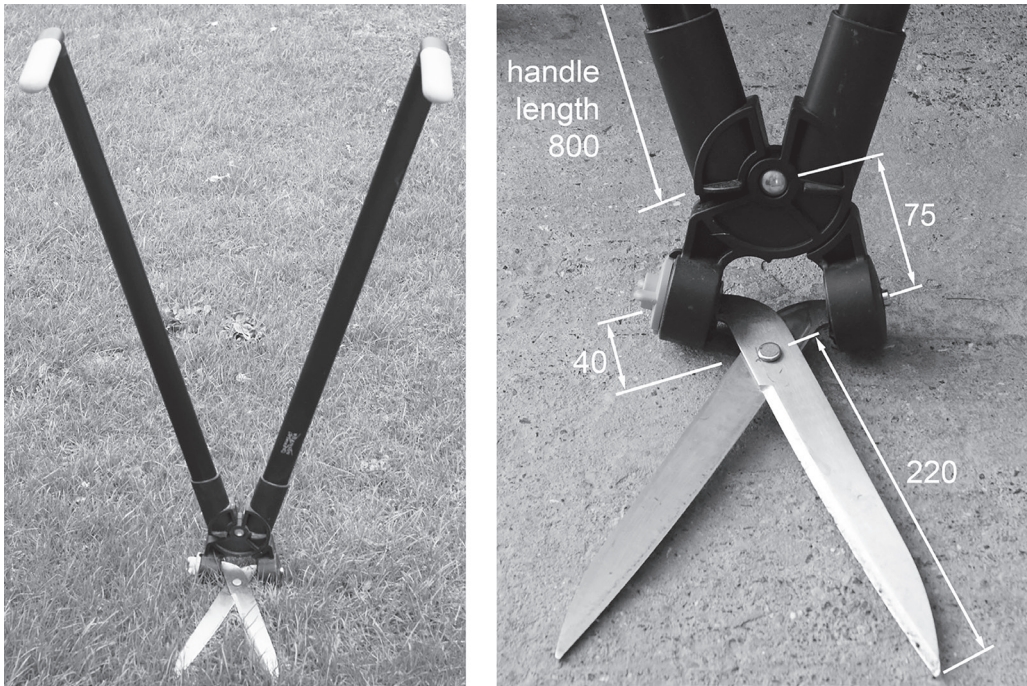**(d)** Fig. 12 shows a pair of garden shears with a compound or double lever action.

Fig. 12

Calculate the mechanical advantage of the shears if the grass is being cut at the tip of the blade.

....

....

....

....

....[3]

12 (a) Fig. 13 shows a voltmeter ready to be connected to a partly completed circuit.

from power supply
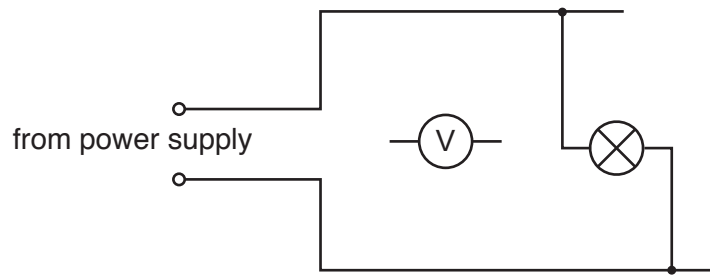
Fig. 13

(i) Complete the connections to the voltmeter. [1]

(ii) The reading on the voltmeter is +9.5 V. The resistance of the signal lamp is 60 Ω.
Calculate the current in the circuit.
Use the formula $I = V/R$

....

....[2]

(iii) Calculate the power of the signal lamp.
Use the formula $P = VI$

....

....[2]

(b) A printed circuit board (PCB) and an IC holder are shown in Fig. 14.

IC holder   all pads tinned

component side   track side
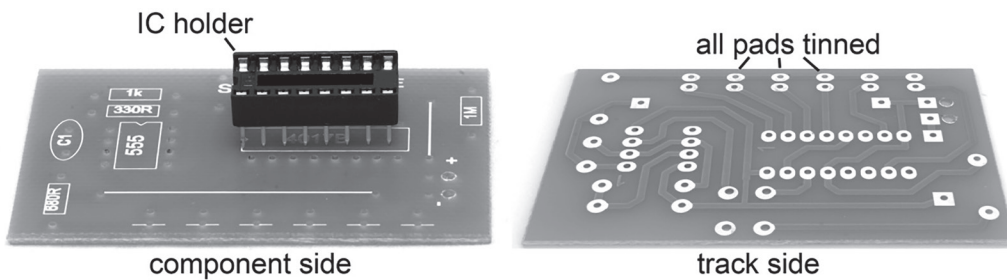
Fig. 14

(i) Give **two** reasons for tinning the pads on a PCB.

1 ....

....

2 ....

....
[2]

(ii) Describe **three** stages in fitting and soldering an IC holder into a PCB.

1 ....

2 ....

3 ....

[3]

(iii) Fig. 15 shows a resistor that has slipped out of position while being soldered into a PCB.
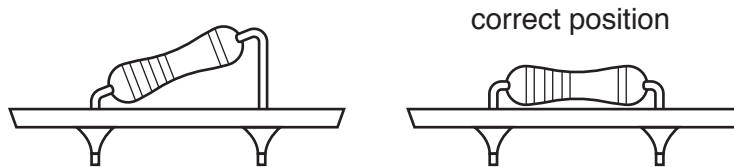
correct position

Fig. 15

Use sketches and notes to describe how the resistor can be moved to the correct position against the PCB.

[3]

(c) Fig. 16 show symbols for two, 2 input OR gates.
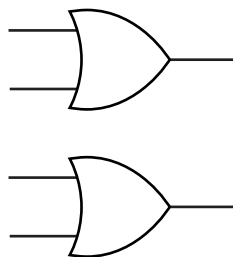
Fig. 16

(i) Connect the 2 input OR gates to make a 3 input OR gate. [1]

(ii) Label the 3 inputs. [1]

(d) Fig. 17 shows the outputs of a programmable IC (PIC) used to control a simple traffic light sequence on two sets of traffic lights at a road works. Each set of lights has only red and green lights for stop and go.

Fig. 17

Sequence of lights on		Logic level of outputs			
set A	set B	out 0	out 1	out 2	out 3
red	green	0	1	1	0
red	red				
green	red				
red	red				
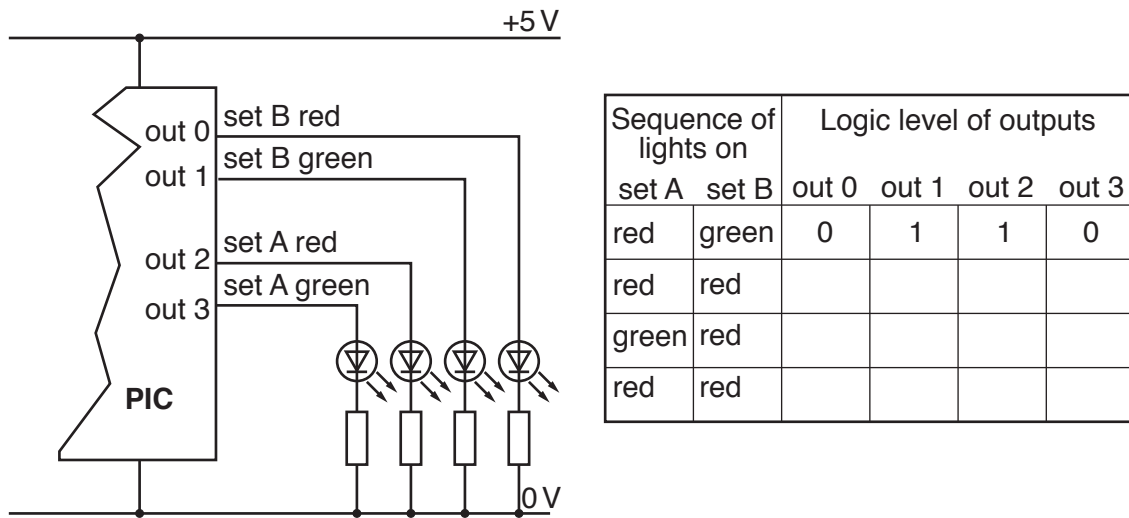
(i) Complete the table to show the logic level of the lights.
The first row has been completed for you. [3]

(ii) Complete Fig. 18 to show a circuit connected to output 2 that uses an NPN transistor to provide a higher current suitable for a high power LED.
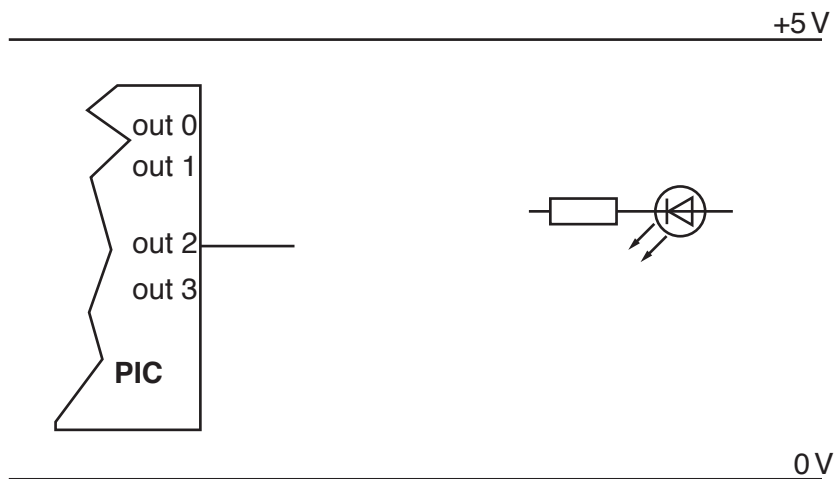
Fig. 18 [4]

(iii) Explain why a PIC system is more suitable for controlling traffic lights than a system using logic ICs.

....

....

....

....

....

....[3]

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