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CAMBRIDGE NATIONALS

Examiners' report

PRINCIPLES IN ENGINEERING AND ENGINEERING BUSINESS

J830, J840

R101 Summer 2022 series

Contents

Introduction

Our examiners' reports are produced to offer constructive feedback on candidates' performance in the examinations. They provide useful guidance for future candidates.

The reports will include a general commentary on candidates' performance, identify technical aspects examined in the questions and highlight good performance and where performance could be improved. A selection of candidate answers is also provided. The reports will also explain aspects which caused difficulty and why the difficulties arose, whether through a lack of knowledge, poor examination technique, or any other identifiable and explainable reason.

Where overall performance on a question/question part was considered good, with no particular areas to highlight, these questions have not been included in the report.

A full copy of the question paper and the mark scheme can be downloaded from OCR.

Advance Information for Summer 2022 assessments

To support student revision, advance information was published about the focus of exams for Summer 2022 assessments. Advance information was available for most GCSE, AS and A Level subjects, Core Maths, FSMQ, and Cambridge Nationals Information Technologies. You can find more information on our website.

R101 series overview

R101 is one of four units that make up the Cambridge National in Engineering Design. Candidates either work towards the J830 Award, completing R101 and R102, or the J840 Certificate, where all four units are mandatory.

The unit aims to provide candidates with knowledge and understanding of the principles of operation of mechanical, electrical and fluid power currently in use in engineering systems. Many of the basic principles can be tackled using practical activities. Study of more specific examples will lead to understanding of how mechanical, electrical and fluid principles apply to everyday engineered products.

R101 is the only externally examined unit, the other units being centre assessed. There were 26 parts within the six questions for June 2022.

To do well on this examination paper, candidates need to have gained and demonstrated knowledge and understanding of physical properties and principles in the three named areas, mechanical, electrical and fluid power. In addition candidates should have knowledge of the systems commonly used to transmit power in engineering. For many of the properties and principles, understanding of practical examples would be beneficial.

More successful candidates attempted all the questions on the paper. The less successful candidates left several questions without a response so could not be given marks. Candidates should be reminded that they cannot access marks if they do not provide a response. All candidates would benefit from using practice questions as part of their preparation.

The Quality of Written Communication (QWC) question asked for discussion, which means introducing points that view the topic from different aspects. It is vital that candidates read the question fully to make sure that they include the required detail in their response.

In certain questions there was clear evidence of gaps in knowledge among the less successful candidates; this has been commented on in the individual question commentary.

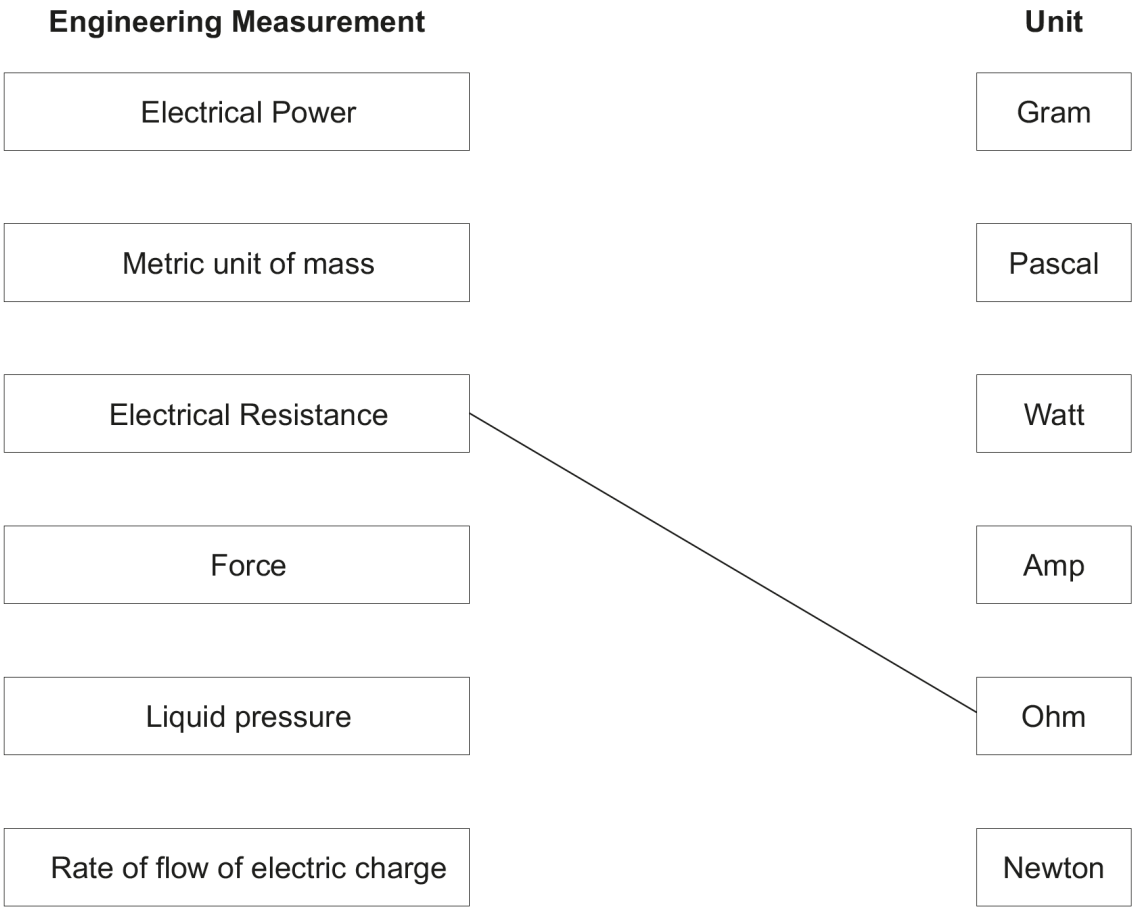
Candidates who did well on this paper generally did the following:	Candidates who did less well on this paper generally did the following:
• answered 'Explain' or 'Discuss' questions using full sentences rather than notes • included all working in calculations • read the questions carefully before starting a response • made use of all information given in figures and tables • wrote legibly.	• did not answer all questions, no response is guaranteed to result in no mark • did not use technical terms in their responses • gave one-word responses • in questions asking for advantages did not provide comparisons.

Question 1 (a)

1 Units are used when describing numerical values in engineering measurement.

(a) Match the engineering measurement with the correct unit.

One has been completed for you.



[4]

The completed answer in this question gave a clear indication of what was required in the response. A high number of candidates answered the question accurately, many gaining all 4 marks. Those who had used a ruler to draw the lines made checking their response easier. Less successful candidates had difficulty distinguishing between the 'Electrical power' link and the 'Rate of flow of electric charge' link.

Key point

Those who had used a ruler to draw the lines made it easier for the candidate and for the examiner when checking the response.

Question 1 (b) (i)

(b) A loaded truck weighing 2000 kilograms travels at a constant speed (velocity) of 5 metres per second on a flat surface.

(i) Calculate the kinetic energy used to move the load.

Use the formula $\mathbf{W_{KE} = ½\ mv^2}$ where m is the mass and v is the velocity.

.....

.....

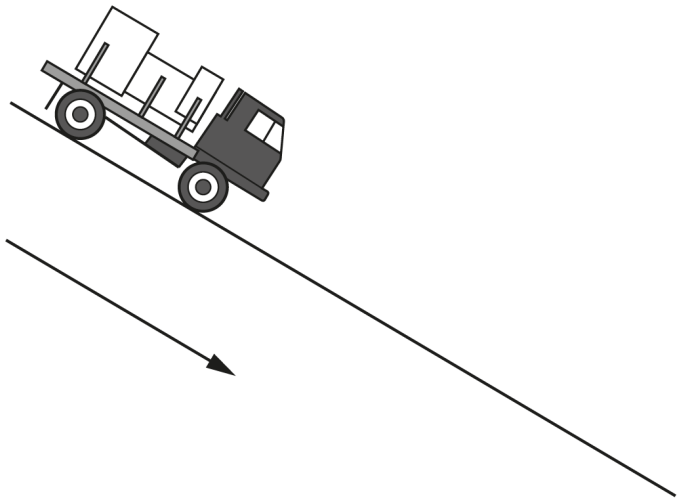
..... **[2]**

The calculation involved using a given formula to calculate the kinetic energy used in moving a load. Less successful candidates had difficulty in substituting values into the formula. Those who could do the substitution usually carried out the calculation accurately to arrive at the correct numeric answer. The second mark in the question was for using the correct unit, (Joules) in the response. Higher performing candidates generally got both marks.

Question 1 (b) (ii)

(ii) **Fig. 1** shows the same truck travelling downwards from the top of a hill.

Fig. 1



State the type of energy force that the truck has, as it travels down the hill.

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

Key point

Kinetic energy is energy that an object has because of its motion.

Gravitational potential energy is that which is held in a vertical position.

Kinetic energy was the correct response although gravitational potential energy was accepted. The second part of the question 'as it travels down the hill', meant that kinetic energy was the accurate response.

Question 1 (c)

(c) Complete the statements below using the correct term to explain mechanical efficiency. Not all of the terms will be used.

energy conversion **energy supplied** **force** **heat**

mechanical advantage **work done**

The mechanical efficiency of an internal combustion engine is found to be 35%.

Mechanical efficiency is the ratio of ..... to the

..... to an engine. Two sources of where

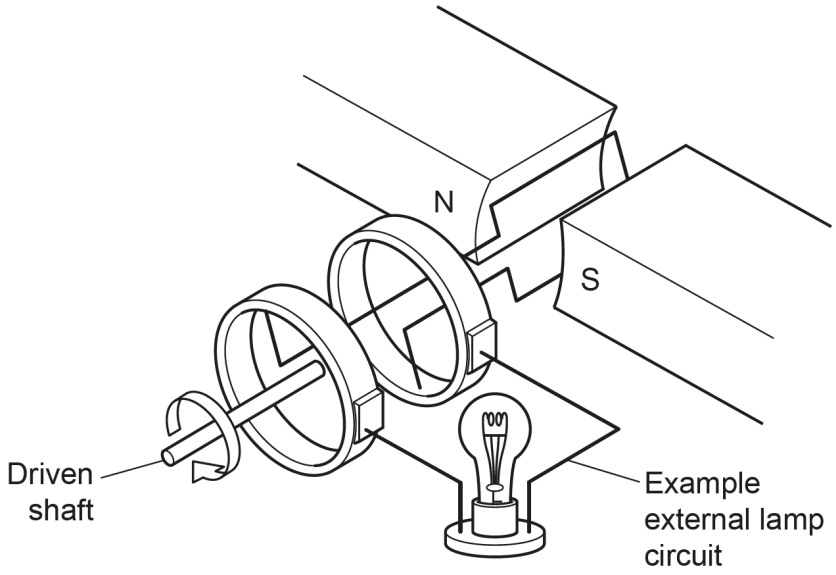
efficiency is lost are ..... and friction. **[3]**

Candidates had to complete statements by adding three correct terms from a list. The last term, 'heat' was generally placed correctly. Many less successful candidates did not identify mechanical efficiency as the ratio of work done to the energy supplied.

Question 2 (a) (i)

2 **Fig. 2** shows a DC electro mechanical device.

Fig. 2



(a) **(i)** Name the device shown.

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

The device shown was a generator, and was correctly identified by higher performing candidates. Some incorrect responses were seen, many of which identified the device as a motor or referred to the light that was attached as an example output device.

Question 2 (a) (ii)

(ii) Add labels to **Fig. 2** to identify **three** component parts of the device. **[3]**

Identification of the component parts of the generator caused some difficulty; the parts named most often were magnets, although very few candidates used the term 'magnetic field'. The North and South poles were marked on the diagram and gave a good clue to what the component was. A few responses identified the wire loop or coil. Very few made any mention of the commutator or brushes.

Question 2 (a) (iii)

(iii) Describe how a current is produced to illuminate the lamp.

.....

.....

.....

.....

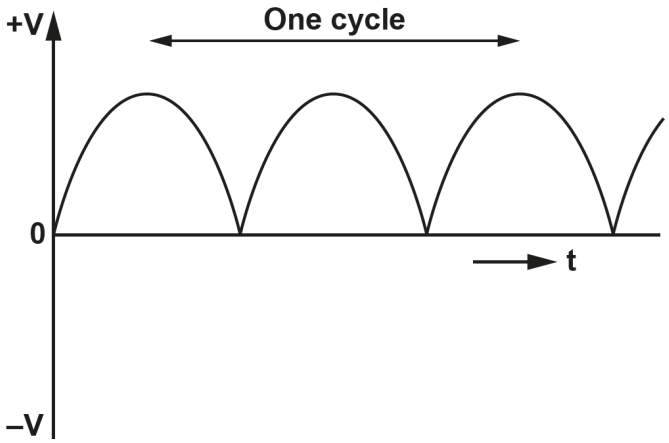
..... **[3]**

Very few candidates across the full range gained credit in this part. The higher performing candidates who had correctly identified the generator were the most successful, even though the mark for describing how the current got from the commutator to the output was given if understanding was evident. A significant number of candidates thought that the device was a motor, and the magnets would cause the drive shaft to spin. It was not clearly understood that the drive shaft provided the movement, and the current was induced into the wire loop (coil).

Question 2 (b)

(b) The output of the device in Fig. 2 is shown as a graph in **Fig. 3**.

Fig. 3



Explain what the graph is showing about the output.

.....

.....

.....

.....

.....

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

The graph showed a half wave rectified DC output. Any responses that recognised it as being a DC output were given 1 mark. Candidates who noted that there was no negative voltage produced were given a second mark; the third mark was for recognition of the half wave rectification.

Question 3 (a) (i)

3 (a) (i) Name an electro mechanical device different to the one shown in **Fig. 2**.

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

This part was asking for an alternative electro mechanical device to the one shown in the Fig. 2 from part 2(a)(i). Any electro mechanical device such as a relay, motor or solenoid would have been given the mark. In addition to these three, which are named in the specification, any other valid response was given a mark.

Question 3 (a) (ii)

(ii) The driven shaft of the device in **Fig. 2** is turned by a belt and a driving pulley.

The driving pulley has a diameter of 160 mm. The driven pulley has a diameter of 80 mm.

Calculate the rotational speed of the driven pulley when the driving pulley is rotating at 900 rpm.

.....

.....

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

This calculation required candidates to know the formula for working out velocity ratio. There was 1 mark for the velocity ratio and 1 for arriving at the correct rotational speed for the driven shaft.

Question 3 (a) (iii)

(iii) State **one** effect of reducing the diameter of the driven pulley on the electrical output of the device in **Fig. 2**.

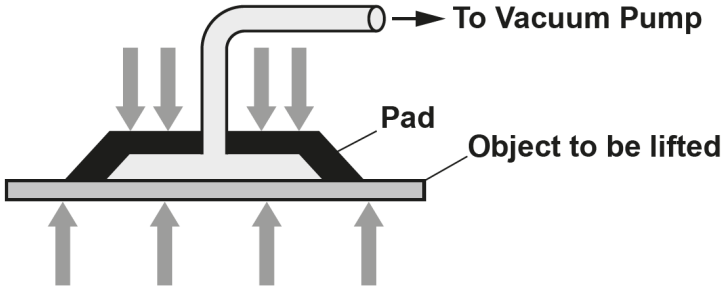
..... **[1]**

The wording of this question was critical to giving a suitable response. An effect on the electrical output was required. A significant proportion of less successful responses had missed the electrical output requirement and only stated the effect on the speed of the driven pulley.

Question 3 (b) (i)

(b) **Fig. 4** shows vacuum mechanical handling equipment.

Fig. 4



(i) Give **two** advantages of using vacuum to handle and move products.

1 .....

.....

2 .....

.....

[2]

Advantages of using vacuum in handling and moving products were asked for. Candidates should try to be specific in cases like this, drawing comparison with alternative methods of handling products. Generic responses such as 'easier to move' were not given any marks. In general candidates should avoid using terms like 'cheap', 'easy' or 'quick' unless they are qualified or compared to another method. There were some good examples given.

Question 3 (b) (ii)

(ii) Describe how vacuum is created and can be used to lift objects.

.....

.....

.....

.....

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

The description of how vacuum is created should have included three separate stages; removal of air from a sealed chamber, mention of atmospheric pressure acting on an object in a vacuum and the suction that is created being used to lift the object. Higher performing candidates generally gained 2 out of the 3 marks.

Exemplar 1

a vacuum pump removes air from the front of the vacuum lifter making the air pressure there less than the surrounding air pressure, this causes a suction effect where the outside air pressure is forcing the product to the lifter **[3]**

Exemplar 1 follows this principle, and demonstrates understanding of the process of creating a vacuum, the description is split into stages and was given full marks.

Question 3 (b) (iii)

(iii) Give **one** application, other than lifting, where vacuum is used in manufacturing.

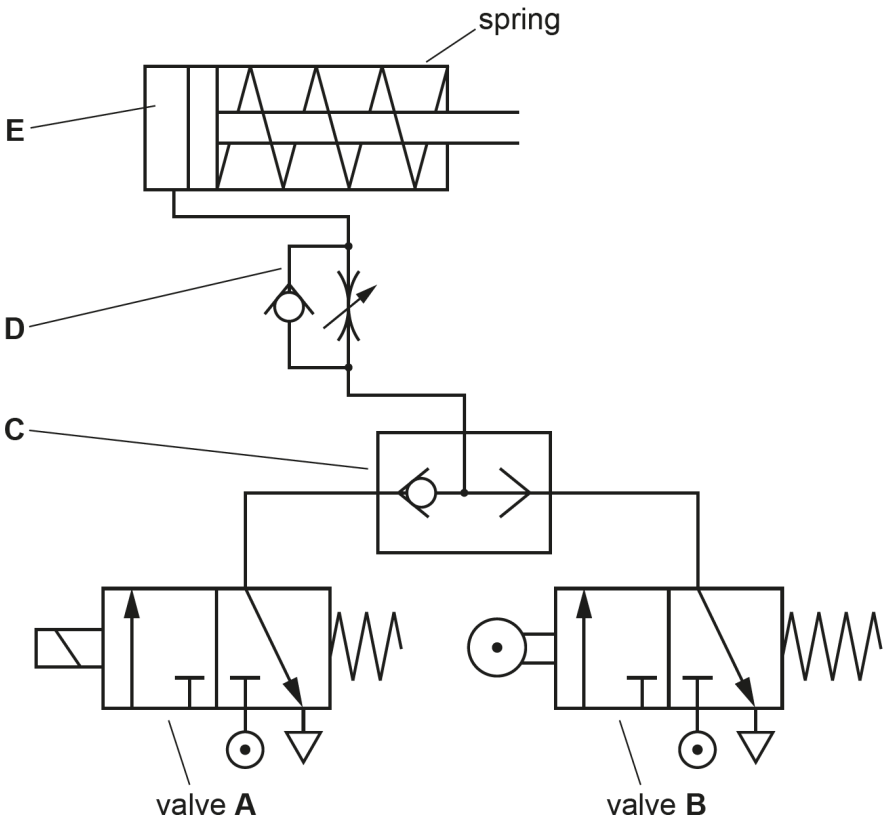
..... **[1]**

All levels of candidate performed well on this question. Varied applications were given but the most popular choices related to candidates' own practical experience, for example vacuum forming or moulding. Where vacuum cleaning was given as the application, the response had to be clear where it is used in manufacturing.

Question 4 (a)

4 **Fig. 5** shows a pneumatic circuit.

Fig. 5



(a) State why component **E** uses a spring.

.....

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

This question concerned pneumatics although some of the responses showed that candidates did not see a distinction between hydraulics and pneumatics. In this part candidates had to recognise the single acting cylinder being used. Any who understood the operation of the component knew that the piston would not retract without help as there is no air supply to do the job. 'The spring is used when instroking' is required.

Question 4 (b)

(b) Add labels to **Fig. 5** to identify the roller tip valve and the flow control valve. **[2]**

Adding labels to the two named components caused problems, particularly for the less successful candidates. The roller tip valve was correctly identified rather more than the flow control valve.

Question 4 (c)

(c) Valves **A** and **B** are both types of 3/2 control valves.

State the number of ports and positions each of these valves has.

..... ports

..... positions

[2]

The number of ports and positions of valves **A** and **B** were correctly stated by a high proportion of middle and higher performing candidates. The number of positions was more consistently correct than the number of ports.

Question 4 (d)

(d) Add a label to **Fig. 5** to identify **one** of the exhaust ports. **[1]**

There were two possible exhaust ports that could have been identified in this part. Less successful candidates frequently identified a main air port.

Question 4 (e)

(e) Use the stages of operation given below to complete the table, giving the stages in the correct sequence for the circuit in **Fig. 5**.

One stage has been completed for you.

Stage	Description of stage of operation
P	After out-stroking, component E in-strokes quickly
Q	Component **C** changes state to allow air to component **D**
R	Component **E** out-strokes slowly
S	The in-stroking cylinder causes air to exhaust through the valve used to operate it
~~T~~	~~The speed of the out-stroking cylinder is controlled by the directional control valve~~
U	Valve **A** or **B** is operated

Sequence	1	2	3	4	5	6
Stage of operation				**T**		

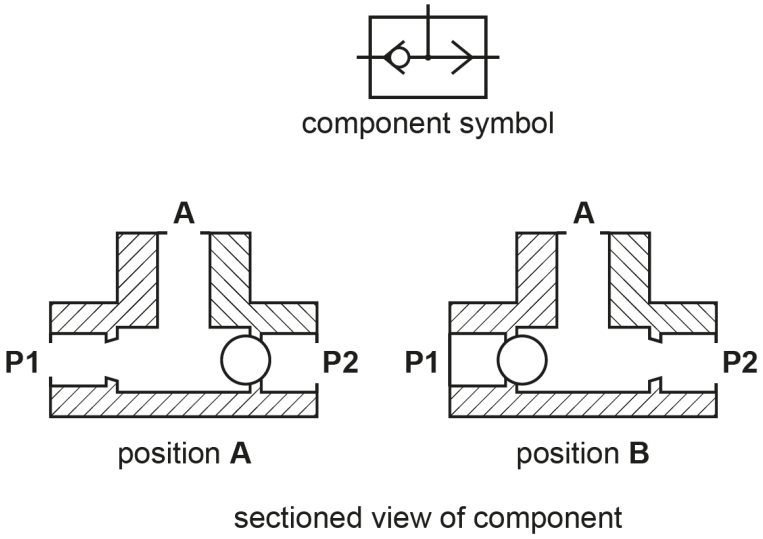
[4]

Understanding the sequence of the stages required careful reading of the descriptions that were given. There were 4 marks available, and most responses were given at least 1 mark.

Question 5 (a) (i)

5 (a) **Fig. 6** shows the symbol and the sectioned view of a component from a fluid power system.

Fig. 6



(i) Give the name of the component shown in **Fig. 6**.

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

Very few candidates identified the shuttle valve correctly. There were a number who did not respond at all, and several with incorrect names given to the component.

Question 5 (a) (ii)

(ii) Describe the operation of the component using the sectioned views in **Fig. 6**.

.....

.....

.....

.....

.....

..... **[4]**

Very few of the less successful candidates gained any marks in this part. Those who had not come across it before could have used the information for stage **Q** in the sequence of operation question. This told them that when component **C**, the shuttle valve, changes state it allows air to component **D**. Several clear responses were seen which described the action of the component very well, gaining all 4 marks. The fact that the ball moves across, sealing the opposite input was frequently noted.

Exemplar 2

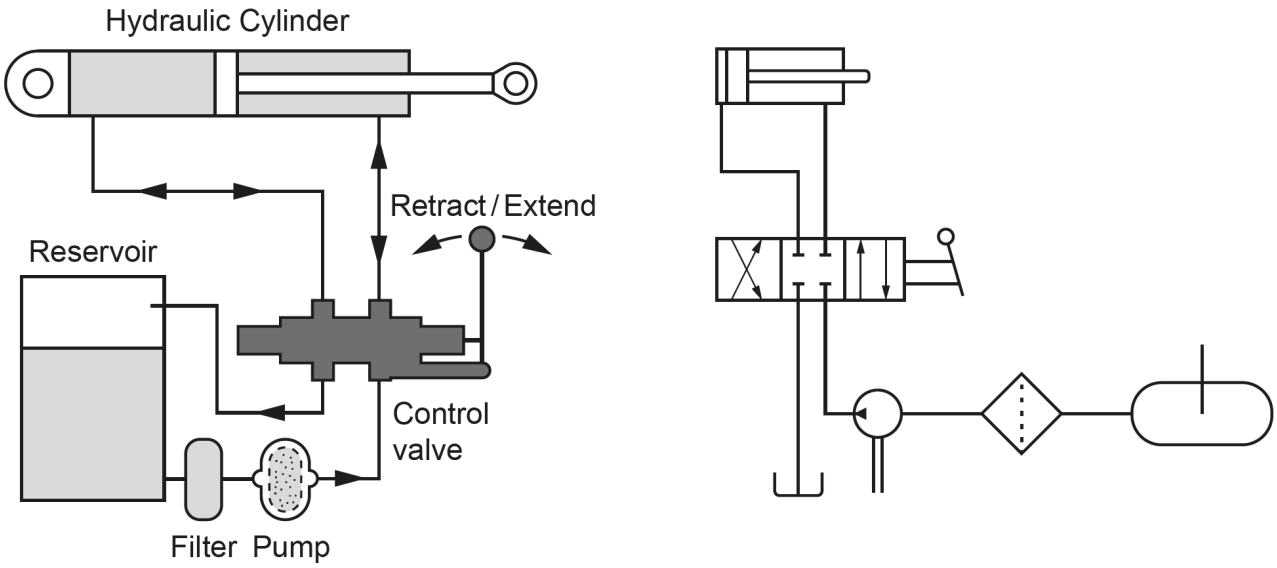
When air or fluid is pushed through P1 the ball will move and close P2 so, the air won't escape, the air flows through to A. If air or fluid is pushed through P2 the ball will move to position B to close off the P1 exit and the air will flow through in to A **[4]**

Exemplar 2 demonstrates a clear understanding of the shuttle valve operation. The description states that the ball moves to close P2 for the first mark. The air from input P1 then leaves at the output, for the second mark. For the third mark the candidate has described what happens when the air input moves to P2. The fourth mark is for recognising that there are two possible inputs for the air and only one possible output. By breaking down the operation and describing it as it would happen the candidate has accessed all the marks.

Question 5 (b) (i)

(b) **Fig. 7** shows a hydraulic circuit and the schematic drawing.

Fig. 7



(i) Explain how the flow of the hydraulic fluid is controlled to extend the actuator.

.....

.....

.....

.....

.....

..... **[4]**

Misconception

This question highlighted the confusion between hydraulic and pneumatic systems among some of the less successful responses. Mention of air pressure in the hydraulics and fluids in the pneumatics question was not uncommon.

Breaking the process down into smaller parts could have been beneficial in many cases. The first part being pressurisation of the fluid, carried out by the pump. Using information from the directional arrows on the diagram, the handle on the control valve either instrokes or outstrokes the piston in the hydraulic cylinder. When the piston is instroking the fluid must go back to the reservoir. With a mixed level of understanding the marks tended to be low.

Question 5 (b) (ii)

(ii) State the purpose of the filter shown in the circuit.

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

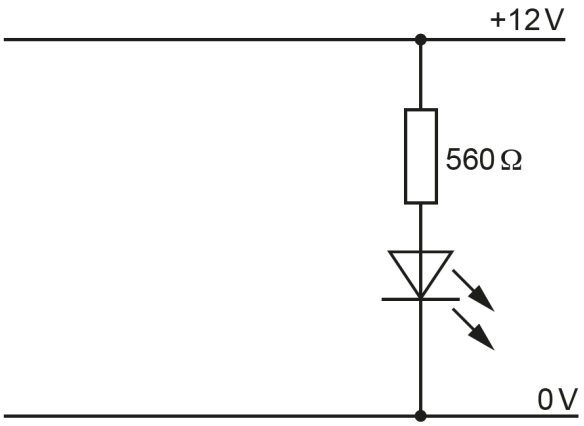
This part was answered accurately across the full range of candidates. Most realised that a filter would be used to remove something from the fluid. The only thing that could need removal is any impurities and particles that have got into the fluid from other parts of the circuit.

Question 6 (a) (i)

6 **(a)** Light emitting diodes (LED) are increasingly replacing traditional filament lamps.

Fig. 8 shows an LED circuit with a resistor in series. There is a 2 V drop across the LED.

Fig. 8



(i) Calculate the current draw in the circuit.

.....

.....

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

In the stem of the question it was stated that there is a 2 V drop across the LED. When carrying out the calculation for current draw in the circuit it was necessary to deduct 2 V from the +12 V supply. If that was not done the maximum available was reduced to 1 mark, using the 'error carried forward' principle. Very few candidates did carry out this deduction. The next part of the calculation was voltage / resistance, and this was completed accurately by higher performing candidates.

Question 6 (a) (ii)

(ii) Give **two** benefits of using LEDs in a cycle lamp.

1 .....

.....

2 .....

.....

[2]

Exemplar 3

1 they are more energy effecient, reducing the amoont of times the batteries need replacing/charging.

2 they are brighter and easier to see.

This question was asking for two benefits of LEDs in a cycle lamp. Most responses, like Exemplar 3, gave two clear benefits, gaining both marks. Several responses did not gain either 1 or both marks because the benefit was not related to a cycle lamp.

Question 6 (b)*

(b)* Discuss how the need for portable energy supply impacts on equipment choice.

.....

.....

.....

.....

.....

..... **[6]**

The question asked candidates to look at the need for portable energy supplies when choosing equipment. Many of the arguments put forward in less successful responses were not relevant because they did not focus on portable energy. Or did not compare the features of the energy supplies with the needs of the equipment. More successful responses used relevant examples of forms of portable energy and types of equipment in their discussion.

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