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PHYSICS

0625/42

Paper 4 Theory (Extended)

May/June 2022

1 hour 15 minutes

You must answer on the question paper.

No additional materials are needed.

INSTRUCTIONS

- Answer **all** questions.
- 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.
- Write your answer to each question 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.
- You should show all your working and use appropriate units.
- Take the weight of 1.0 kg to be 10 N (acceleration of free fall = 10 m/s^2).

INFORMATION

- The total mark for this paper is 80.
- The number of marks for each question or part question is shown in brackets [].

This document has **16** pages. Any blank pages are indicated.

1 Fig. 1.1 shows an electrically powered bicycle.

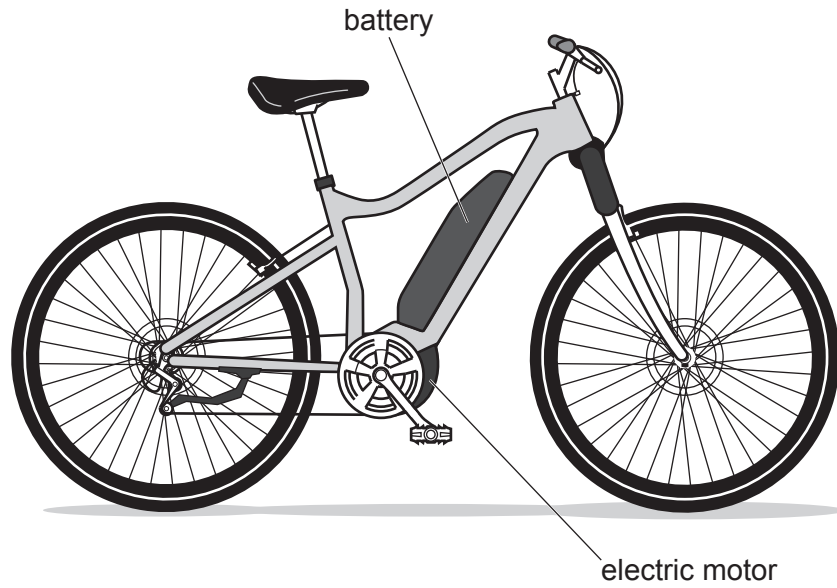


Fig. 1.1

When fully charged, the battery can deliver a power of 600 W for 60 min.

(a) (i) Calculate the energy, in joules, stored in the battery when fully charged.

energy = J [3]

(ii) State the form of energy stored by the battery.

..... [1]

(b) The bicycle has a motor with an electrical input power of 250 W.

Calculate the time for which the battery can power the bicycle.

time = [2]

(c) Consider this bicycle compared to a small motorcycle.

State **two** environmental benefits of the electrically powered bicycle.

1.

2.

[2]

[Total: 8]

- 2 Fig. 2.1 shows an object of mass 2.0 kg on a bench. This object is connected by a cord, passing over a pulley, to an object of mass 3.0 kg.

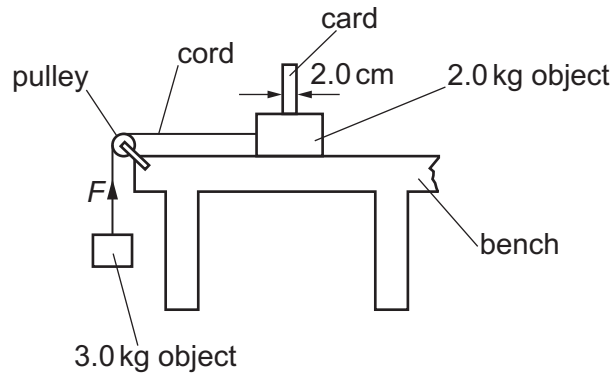


Fig. 2.1

The 2.0 kg object is released from rest and accelerates at 4.0 m/s^2 .

- (a) Calculate the resultant force acting on the 2.0 kg object.

force = [2]

- (b) Calculate the upward force F exerted by the cord on the 3.0 kg object.

force F = [3]

- (c) The objects have a constant acceleration.

- (i) Show that the speed of the objects 0.80 s after release is 3.2 m/s.

[2]

- (ii) A card, of width 2.0 cm, is fixed to the 2.0 kg object. As the 2.0 kg object moves to the left, the card passes through a beam of light that is perpendicular to the card.

Using the speed given in (c)(i), calculate the time taken for the card to pass through the beam of light.

time = [2]

[Total: 9]

[Turn over

- 3 (a) Fig. 3.1 shows water in a river moving parallel to the river bank at 4.0 m/s and a canoe travelling in the river.

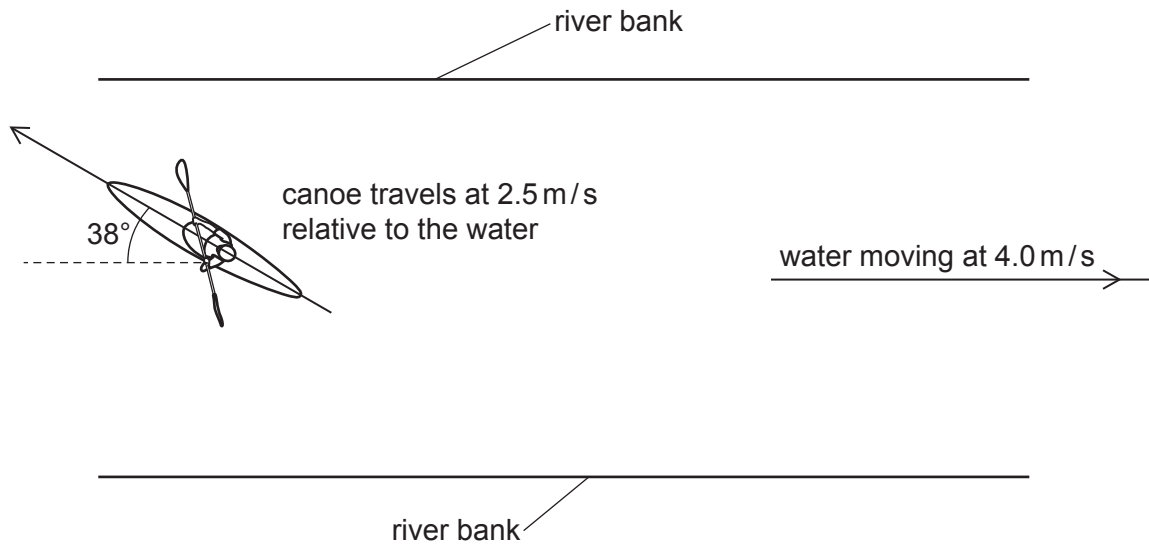


Fig. 3.1

The canoe travels at 2.5 m/s relative to the water and heads at an angle of 38° to the river bank.

Draw a scale diagram to determine the canoe's resultant velocity and state the scale you used.

scale

magnitude of resultant velocity

direction of resultant velocity (angle from the river bank)

[4]

(b) The mass of the canoeist is 65 kg.

Calculate her kinetic energy when travelling on still water at 2.5 m/s.

energy = [2]

[Total: 6]

- 4 (a) State and explain the **two** features of a liquid-in-glass thermometer that are necessary for linearity.

statement 1

explanation

statement 2

explanation

[4]

- (b) The value of the heat capacity of the hot junction of a thermocouple thermometer is important in ensuring that it can measure temperature changes very rapidly.

Explain why.

.....

.....

.....

..... [2]

- (c) The hot junction of a thermocouple thermometer has a heat capacity of $0.11 \text{ J/}^\circ\text{C}$.

Calculate the thermal energy required to increase the temperature of the hot junction from 20°C to 345°C .

energy = [3]

[Total: 9]

5 Sound waves are longitudinal and electromagnetic waves are transverse.

(a) A sound wave used for a medical examination has a frequency of 1.5 MHz.

(i) State and explain what type of sound wave this is.

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

(ii) The wave travels through soft human tissue at a speed of 1.3 km/s.

Calculate the wavelength of the wave in soft human tissue.

wavelength = [3]

(b) Describe **one** use of X-rays in medicine.

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

[Total: 7]

6 Fig. 6.1 is a full-size ray diagram showing the formation of an image by a thin glass lens.

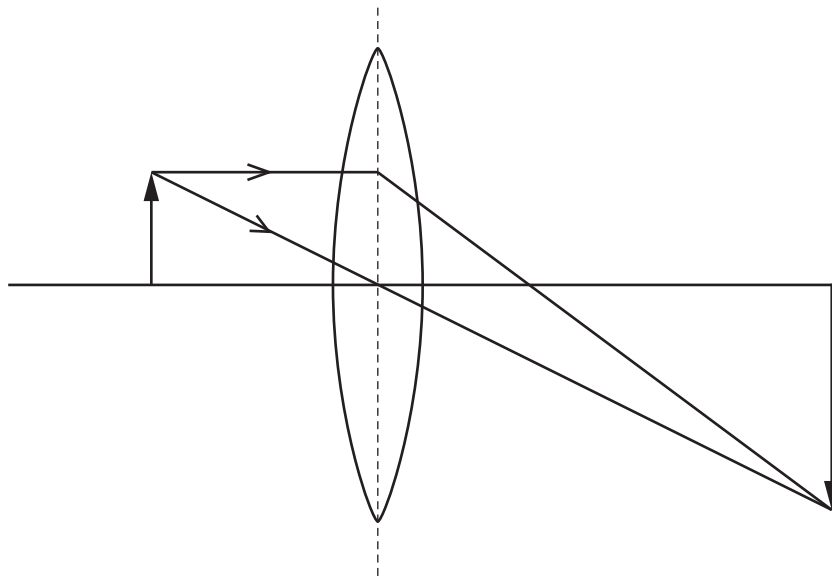


Fig. 6.1 (full size)

(a) Determine the focal length of the lens.

focal length = [1]

(b) Circle **three** items in the list which describe the nature of the image formed.

- | | | | |
|-----------------|------------------|-------------------|-----------------|
| enlarged | same size | diminished | inverted |
| upright | real | virtual | |

[3]

(c) State **one** feature of a virtual image.

..... [1]

[Total: 5]

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- 7 Fig. 7.1 shows a small plotting compass which is aligned with the magnetic field between magnetic poles A and B of a U-shaped magnet.

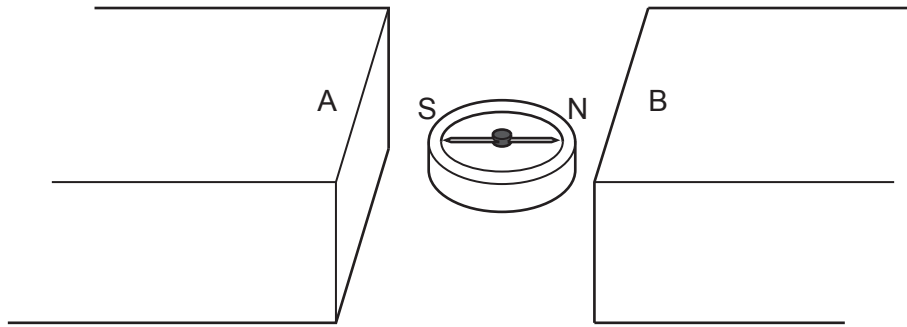


Fig. 7.1

- (a) State the polarity of the poles.

pole A

pole B

[1]

- (b) Fig. 7.2 shows a wire, placed between two poles, carrying a current in the direction of the arrow.

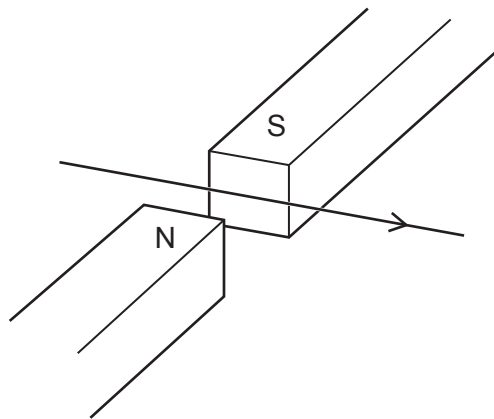


Fig. 7.2

On Fig. 7.2, draw an arrow to show the direction of the force on the wire due to the magnetic field.

[2]

(c) Fig. 7.3 shows a β -particle moving in the direction of the arrow between the same two poles.

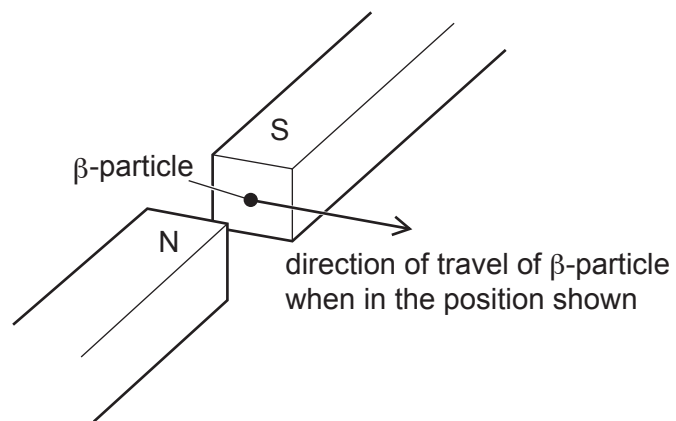


Fig. 7.3

On Fig. 7.3, draw an arrow to show the direction of the force on the β -particle due to the magnetic field. [2]

[Total: 5]

- 8 Fig. 8.1 shows how the electromotive force (e.m.f.) of a 60Hz alternating current (a.c.) power supply varies with time.

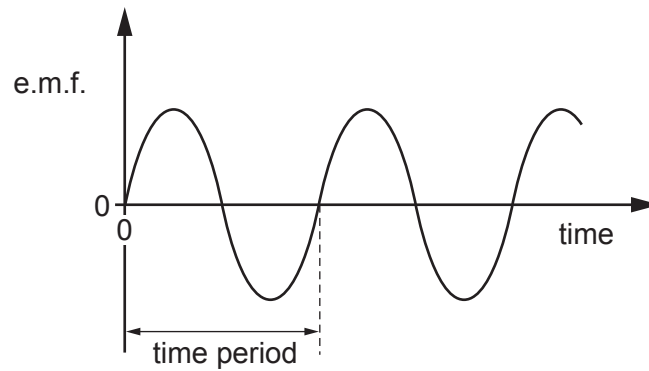


Fig. 8.1

- (a) Calculate the time period of the a.c.

time period = [1]

- (b) Fig. 8.2 shows this power supply connected in a circuit.

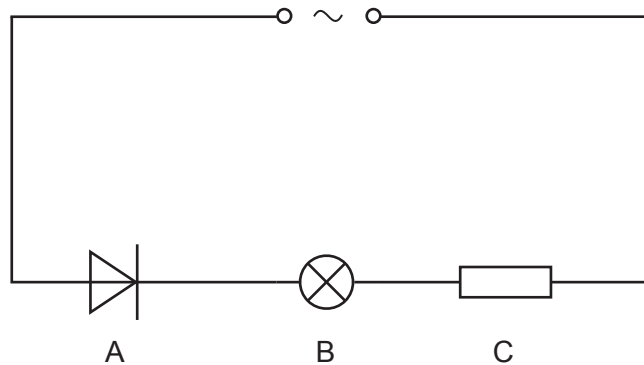


Fig. 8.2

- (i) State the name of component A.

..... [1]

- (ii) In each time period of the a.c., 1.5×10^{17} electrons pass through component A. The charge on an electron is $1.6 \times 10^{-19} \text{C}$.

Calculate the average current in the circuit during one time period.

current = [3]

(c) On Fig. 8.3:

1. mark, with an arrow labelled E, the direction of the electron flow through component B
2. mark, with an arrow labelled I, the direction of the conventional current in component C.

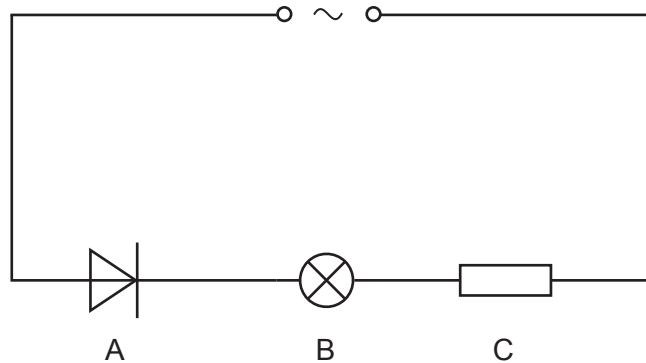


Fig. 8.3

[2]

(d) Fig. 8.4 shows a circuit with components B and C connected to a direct current (d.c.) power supply of e.m.f. 12V.

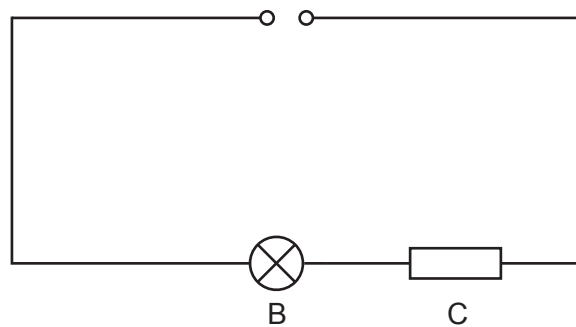


Fig. 8.4

The current in the circuit is 0.35A.

Calculate the power delivered by the power supply to the circuit.

power = [2]

[Total: 9]

9 Fig. 9.1 shows a circuit with a 3-position switch.

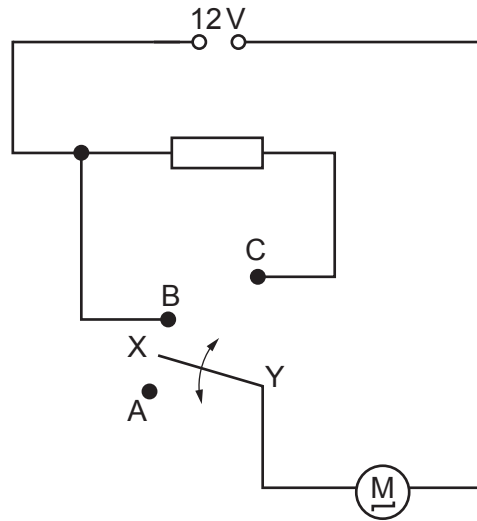


Fig. 9.1

The moving part of the switch is always connected to point Y around which it pivots. The other end of the moving part, labelled X, can be connected to one of the points A, B or C.

(a) The resistance of the motor is $2.0\ \Omega$ and the resistance of the resistor is $3.0\ \Omega$.

Determine the current in the motor when the switch is connected to:

(i) point A

current = [1]

(ii) point B

current = [2]

(iii) point C.

current = [2]

(b) Two resistors of resistance $2.0\ \Omega$ and $3.0\ \Omega$ are connected in parallel.

Calculate the combined resistance of the resistors in this arrangement.

resistance = [3]

[Total: 8]

10 Fig. 10.1 is a simplified diagram of a digital circuit. The output of logic gate Y controls a buzzer.

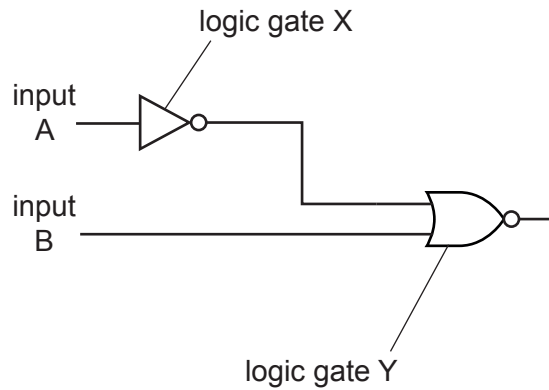


Fig. 10.1

(a) Complete Table 10.1, the truth table for the circuit.

Table 10.1

input A	input B	output of X	output of Y
0	0		
0	1		
1	0		
1	1		

[3]

(b) Input A is the output of a humidity sensor which gives logic 1 when the humidity is high and logic 0 when the humidity is low.

Input B is the output of a light sensor which gives logic 1 in bright light and logic 0 in darkness. The buzzer sounds when the output of Y is logic 1.

State the conditions of humidity and light when the buzzer is on.

..... [1]

(c) The output of the digital circuit alone is **not** able to operate the buzzer.

Ring the component from the list that must be connected between the output of the digital circuit and the buzzer.

- fuse heater relay resistor thermistor**

Explain your answer.

.....

[3]

[Total: 7]

- 11 (a) Fig. 11.1 shows the paths of three α -particles moving towards a thin gold foil. Four gold nuclei are shown.

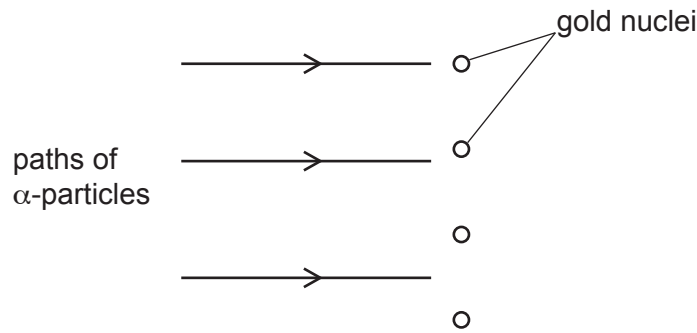


Fig. 11.1 (not to scale)

- (i) On Fig. 11.1, complete the paths of the **three** α -particles. [3]

- (ii) State the sign of the charge on the α -particles.

..... [1]

- (b) The nuclide notation for a nucleus of gold-198 is ${}_{79}^{198}\text{Au}$.

State the numbers of electrons, neutrons and protons in a neutral atom of gold-198.

number of electrons =

number of neutrons =

number of protons =

[3]

[Total: 7]

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