Rewarding Learning

ADVANCED
General Certificate of Education

Centre Number

Candidate Number

Physics

Assessment Unit A2 2
assessing

Fields, Capacitors and Particle Physics

[APH21]

APH21

Assessment

Assessment Level of Control:
Tick the relevant box (✓)

Controlled Conditions	
Other	

TIME

2 hours.

INSTRUCTIONS TO CANDIDATES

Write your Centre Number and Candidate Number in the spaces provided at the top of this page.
You must answer the questions in the spaces provided.
Do not write outside the boxed area on each page or on blank pages.
Complete in black ink only. **Do not write with a gel pen.**
Answer **all seven** questions.

INFORMATION FOR CANDIDATES

The total mark for this paper is 100.
Quality of written communication will be assessed in Question **5(a)**.
Figures in brackets printed down the right-hand side of pages indicate the marks awarded to each question or part question.
Your attention is drawn to the Data and Formulae Sheet which is inside this question paper.
You may use an electronic calculator.

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1 **(a)** Kepler's third law states that the ratio of $\frac{T^2}{r^3}$ is a constant for every planet.

State and clearly **explain** what the letters T and r represent in Kepler's third law.

T = ____________________

____

____

r = ____________________

____

____________________ [4]

(b) Kepler's third law can be written as **Equation 1.1** where k is a constant.

$$r^3 = kT^2$$ **Equation 1.1**

Use Newton's law of gravitation to find an expression for the constant k. Clearly show all your working and identify any additional symbols used in the expression for k.

k = ____________________

____

____

____________________ [5]

2 (a) (i) State, in words, Coulomb's law for the force between two point charges.

____

____

____ [2]

(ii) The force between two point charges of equal magnitude is 5.6×10^{-4} N when they are placed 5.0 cm apart in air. Calculate the magnitude of each charge.

Charge = ____________ C [3]

(iii) State one change that would result in the force being doubled.

____ [1]

(b) **Fig. 2.1** shows a **positive** charge of magnitude 3.2 nC.

(i) Sketch the electric field around the charge.

Fig. 2.1

[2]

(ii) Calculate the distance from the charge at which the electric field strength has a magnitude of 720 N C^{-1}.

Distance = ____________ m [3]

(iii) Calculate the initial acceleration of a proton placed at the distance calculated in **(b)(ii)** and state the direction of the acceleration relative to the charge.

Acceleration = ____________________ m s^{-2}

Direction = ____________________________ [6]

(iv) The proton moves for a time after the initial acceleration. Can the equations of motion be used to calculate the distance the proton moves in this time? Explain your answer.

____

____

____ [2]

3 **(a)** **Table 3.1** gives the names of three fundamental particles and three of the fundamental forces.

Table 3.1

Particle	**Fundamental force**		
	Strong nuclear force	Weak nuclear force	Electromagnetic force
quark			
neutrino			
electron			

(i) Why are these particles described as fundamental?

____

____ [1]

(ii) In **Table 3.1**, place a tick (✔) in any relevant cells to show which of the fundamental forces acts on each particle. Each row can have more than one tick. [3]

(iii) There is one fundamental force missing from **Table 3.1**. Name the force and the exchange particle associated with it.

Fundamental force ______________________________

Exchange particle ______________________________ [2]

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(b) To investigate particle annihilation, particles must be accelerated to high speeds in a particle accelerator.

(i) Describe what happens in particle annihilation.

____

____

____ [3]

(ii) Name a type of particle accelerator that is suitable to accelerate particles to the high speeds required for investigations such as this.

____ [1]

(iii) What property must the particles have to be accelerated by particle accelerators such as this?

____ [1]

4 The power source of a camera flash is a 1.5 V d.c. battery. The flash circuit converts this to 1.5 V a.c. which is then increased to 300 V a.c.

(a) (i) Assuming there are no energy losses, describe how the potential difference can be increased from 1.5 V a.c. to 300 V a.c.

____

____

____

____ [3]

The 300 V a.c. is converted to 300 V d.c. to fully charge a 1200 μF capacitor in the flash unit.

(ii) Calculate the number of electrons that move to the negatively charged capacitor plate during the process of fully charging the capacitor.

Number of electrons = ____________ [4]

(iii) Calculate the energy stored by the capacitor when it is fully charged.

Energy = ________________ J [3]

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(b) (i) When the capacitor is discharged, the flash operates until the voltage across the capacitor falls to 210 V. If the flash duration is 0.8 ms, calculate the resistance of the discharge circuit.

Resistance = ______________________ Ω [3]

(ii) On the grid of **Fig. 4.1** draw a graph showing how the voltage varies with time as the capacitor discharges.

Use the space to the left of **Fig. 4.1** to show your calculations of the values required.

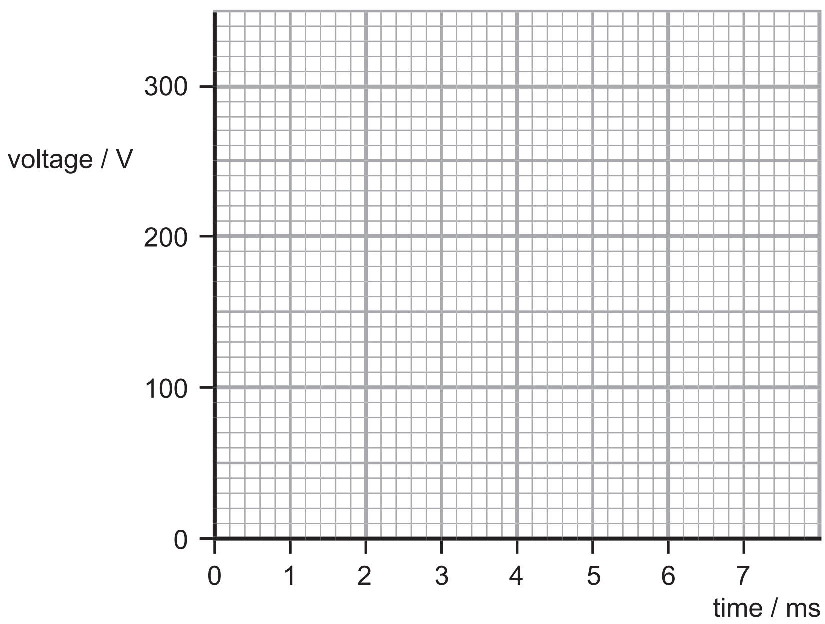

Fig. 4.1

[4]

[Turn over

Quality of written communication will be assessed in part (a) of this question.

5 **(a)** **Fig. 5.1** shows a basic a.c. generator. Describe how it works to generate an alternating e.m.f.. In your description, include the name and function of component X.

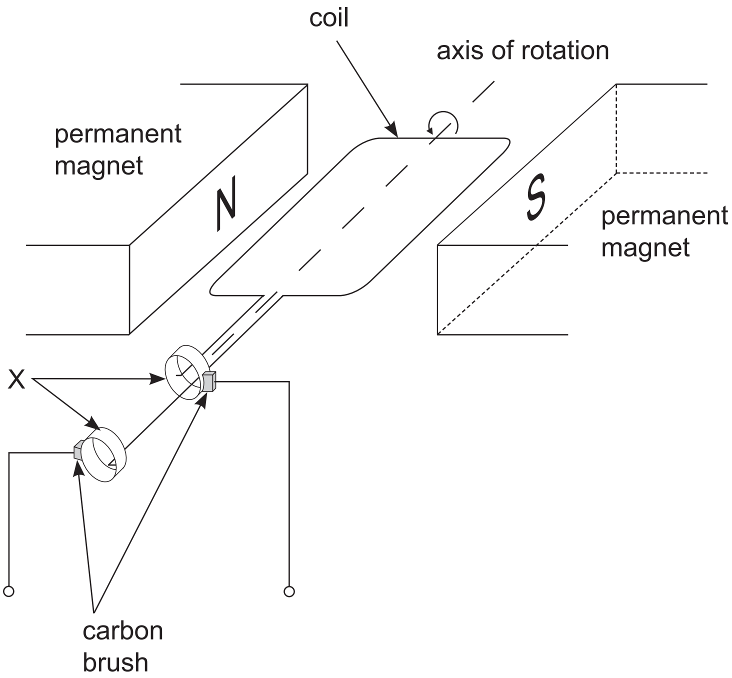

Fig. 5.1

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____ [6]

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(b) **Fig. 5.2** shows two positions of the rotating coil, viewed along the axis of rotation.

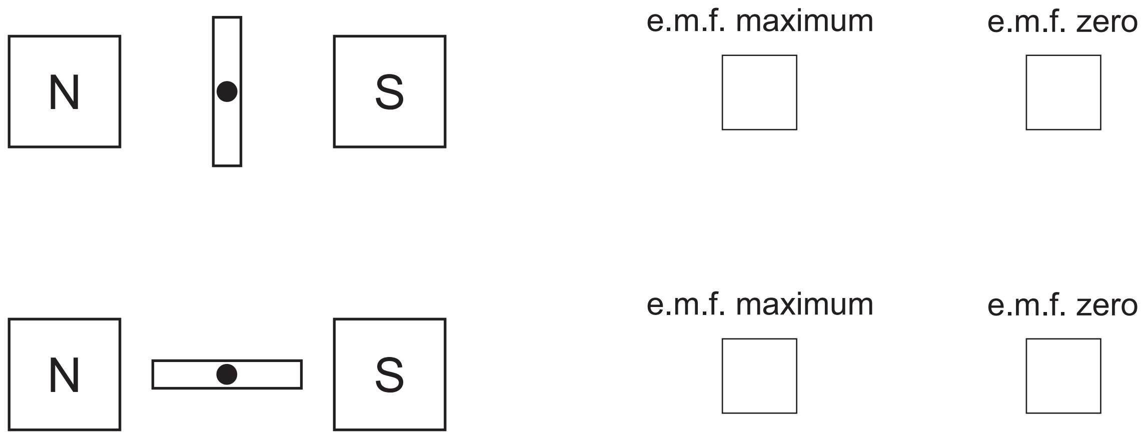

Fig. 5.2

(i) Tick the correct box in each case to show whether the e.m.f. generated is maximum or zero. [1]

(ii) The magnet in the a.c. generator has a magnetic flux density of 0.76 T. The area of the coil is 25 cm^2 and there are 40 turns on the coil. If the coil rotates once in 0.60 seconds, calculate how long it takes for the e.m.f. generated to change from 0 V to 0.52 V.

Time = ________________ s [4]

(c) The North pole of a bar magnet is moved towards a copper pipe as shown in **Fig. 5.3a**. As the magnet approaches the copper pipe a current is induced.

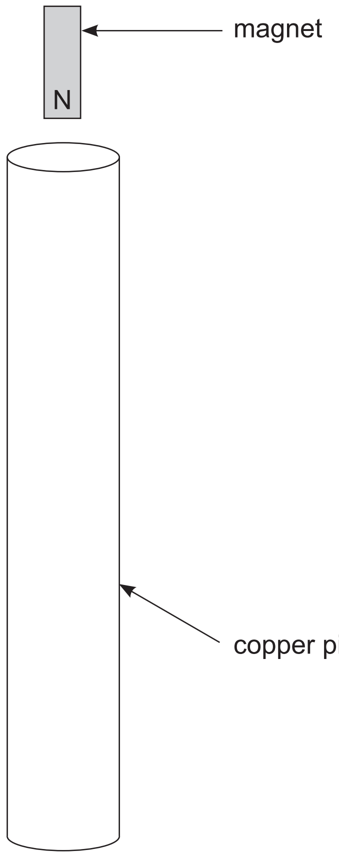

Fig. 5.3a

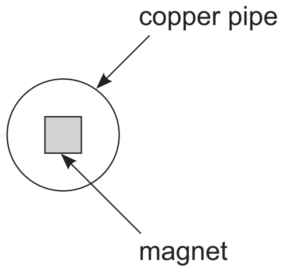

Fig. 5.3b

When viewed from above, as shown in **Fig. 5.3b**, in what direction is the induced current? Explain your answer.

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____ [4]

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(Questions continue overleaf)

[Turn over

6 In 1992, the experimental ship Yamato 1 became the first ship to use superconducting magnetohydrodynamics (MHD) to cause propulsion. In MHD, a magnetic field is applied to an electrically conducting fluid, such as seawater, to create a force in the fluid. This eliminates motors and propellers with the potential to be a low-noise reliable system.

In tests, a ship was tied to a bollard using a rope and the thrusters turned on. The maximum tension T in the rope was measured to be 16.6 kN when the rope was at an angle of 20° as shown in **Fig. 6.1**.

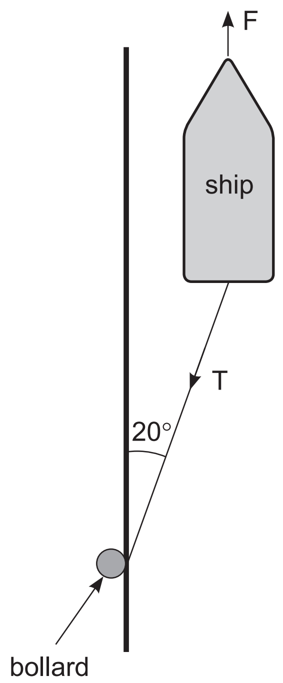

Fig. 6.1

(a) The forward force F on the ship is provided by two thrusters. Calculate the forward force provided by each thruster when the tension T in the rope is at a maximum. Give your answer in kN.

Force = ____________ kN [3]

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(b) Each thruster consists of 6 tubes of equal diameter filled with seawater. A cross section of one of the tubes of diameter 0.28 m is shown in **Fig. 6.2**. The p.d. applied across the electrodes X and Y causes a current of 2000 A to pass through the seawater in the tube. A strong magnetic field acts between the poles of an electromagnet.

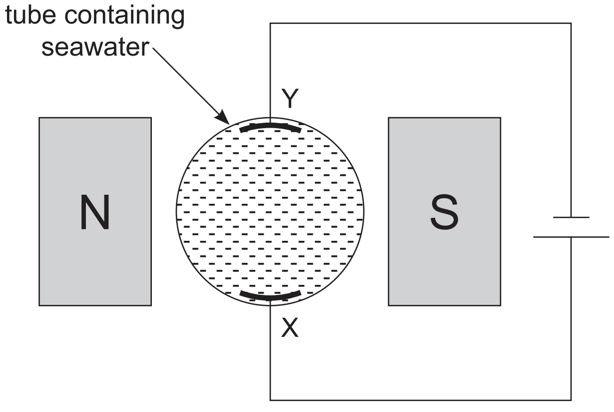

Fig. 6.2

(i) On **Fig. 6.2** draw an arrow between the electrodes X and Y to show the direction of the electric current in the seawater. [1]

(ii) In what direction is the force on the seawater in **Fig. 6.2**?

_______________________________________ [1]

(iii) Assume the diameter of the tube is equivalent to the length of the conductor in the magnetic field. Calculate the magnetic flux density of the electromagnet.

Magnetic flux density = ____________________ T [4]

[Turn over

(c) The knot is a unit of speed equal to one nautical mile per hour, which has a value of 1.852 km h^{-1}.

Calculate the time taken for the ship to reach a speed of 8.0 knots from rest if the acceleration of the ship is 0.082 m s^{-2}.

Time = ___________ s [4]

(d) The strong magnetic field required in using MHD for practical applications has only been possible since the introduction of superconductors. Explain why superconductors are necessary in the use of MHD and outline how the superconducting state is achieved.

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____ [4]

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7 **(a)** An alpha particle, a beta particle and a neutron, moving at the same velocity, enter a region where a magnetic field acts perpendicular to their motion. Describe the difference in the paths followed by the particles.

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____ [4]

(b) (i) The velocity of the particles when they enter the magnetic field is 1.4×10^5 m s^{-1}. Calculate the radius of the circle that the alpha particle follows when it enters the field if the strength of the magnetic field is 49 mT.

Radius of circle = _______________ m [5]

(ii) Calculate the time taken for the alpha particle to emerge from the field if it leaves the field travelling in the opposite direction to the direction it entered.

Time taken = _______________ s [3]

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For Examiner's use only	
Question Number	Marks
1	
2	
3	
4	
5	
6	
7	
Total Marks	

Examiner Number

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