Centre Number						Candidate Number				
Surname										
Other Names										
Candidate Signature										

General Certificate of Education
Advanced Level Examination
June 2010

Physics A PHYA4/1

Unit 4 Fields and Further Mechanics
Section A

Friday 18 June 2010 9.00 am to 10.45 am

In addition to this paper you will require:
- an objective test answer sheet
- a black ink or black ball-point pen
- a calculator
- a question paper/answer book for Section B (enclosed)
- a Data and Formulae Booklet.

Time allowed
- The total time for both sections of this paper is 1 hour 45 minutes. You are advised to spend approximately 45 minutes on this section.

Instructions
- Use black ink or black ball-point pen. Do **not** use pencil.
- Answer **all** questions in this section.
- For each question there are four responses. When you have selected the response which you think is the most appropriate answer to a question, mark this response on your answer sheet.
- Mark all responses as instructed on your answer sheet. If you wish to change your answer to a question, follow the instructions on your answer sheet.
- Do all rough work in this book **not** on the answer sheet.

Information
- The maximum mark for this section is 25.
- Section A and Section B of this paper together carry 20% of the total marks for Physics Advanced.
- All questions in Section A carry equal marks. No deductions will be made for incorrect answers.
- A *Data and Formulae Booklet* is provided as a loose insert.
- The question paper/answer book for Section B is enclosed within this question paper.

Multiple choice questions

Each of Questions **1** to **25** is followed by four responses, **A**, **B**, **C** and **D**. For each question select the best response and mark its letter on the answer sheet.

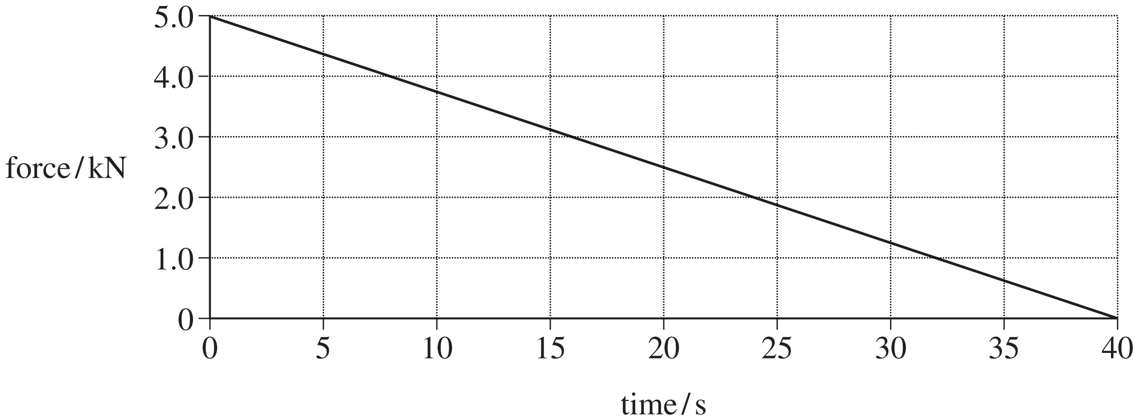
You are advised to spend approximately **45 minutes** on this section.

1 Which one of the following statements is correct?

The force acting on an object is equivalent to

A its change of momentum.
B the impulse it receives per second.
C the energy it gains per second.
D its acceleration per metre.

2 The graph shows how the force on a glider of mass 2000 kg changes with time as it is launched from a level track using a catapult.



Assuming the glider starts at rest what is its velocity after 40 s?

A $2.5\ \mathrm{m\,s^{-1}}$
B $10\ \mathrm{m\,s^{-1}}$
C $50\ \mathrm{m\,s^{-1}}$
D $100\ \mathrm{m\,s^{-1}}$

3 A gas molecule of mass m in a container moves with velocity v. If it makes an elastic collision at right angles to the walls of the container, what is the change in momentum of the molecule?

A zero
B $\frac{1}{2}mv$
C mv
D $2\,mv$

4 A mass on the end of a string is whirled round in a horizontal circle at increasing speed until the string breaks. The subsequent path taken by the mass is

A a straight line along a radius of the circle.
B a horizontal circle.
C a parabola in a horizontal plane.
D a parabola in a vertical plane.

5 A particle of mass m moves in a circle of radius r at uniform speed, taking time T for each revolution. What is the kinetic energy of the particle?

A $\dfrac{\pi^2 mr}{T^2}$

B $\dfrac{\pi^2 mr^2}{T^2}$

C $\dfrac{2\pi^2 mr^2}{T}$

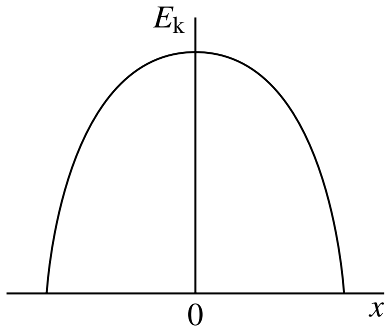
D $\dfrac{2\pi^2 mr^2}{T^2}$

6 A body moves with simple harmonic motion of amplitude 0.90 m and period 8.9 s. What is the speed of the body when its displacement is 0.70 m?

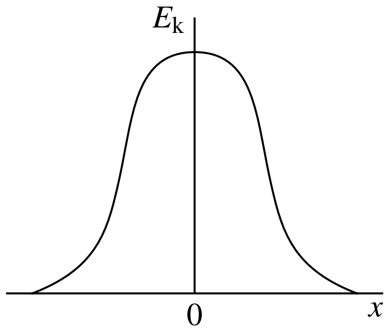
A $0.11\,\mathrm{m\,s^{-1}}$
B $0.22\,\mathrm{m\,s^{-1}}$
C $0.40\,\mathrm{m\,s^{-1}}$
D $0.80\,\mathrm{m\,s^{-1}}$

Turn over for the next question

7 Which graph, **A** to **D**, shows the variation of the kinetic energy, E_k, with displacement x for a particle performing simple harmonic motion?



A



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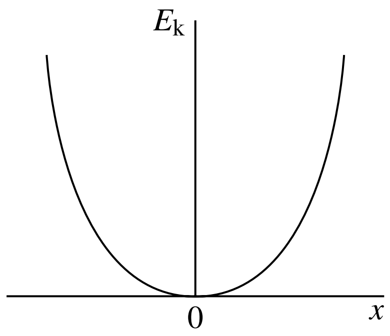
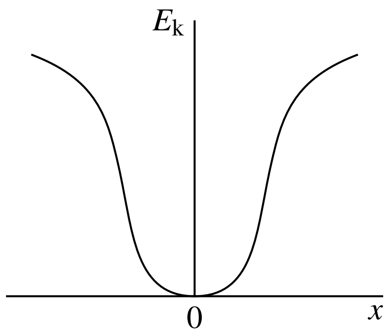


C



D

8 The time period of oscillation of a simple pendulum of length l is the same as the time period of oscillation of a mass M attached to a vertical spring. The length and mass are then changed. Which row, **A** to **D**, in the table would give a simple pendulum with a time period twice that of the spring oscillations?

	new pendulum length	**new mass on spring**
A	$2l$	$2M$
B	$2l$	$\frac{M}{2}$
C	$\frac{l}{2}$	$2M$
D	$\frac{l}{2}$	$\frac{M}{2}$

9 A projectile moves in a gravitational field. Which one of the following is a correct statement about the gravitational force acting on the projectile?

A The force is in the direction of the field.
B The force is in the opposite direction to that of the field.
C The force is at right angles to the field.
D The force is at an angle between 0° and 90° to the field.

10 The gravitational potential difference between the surface of a planet and a point P, 10 m above the surface, is $8.0\,\mathrm{J\,kg^{-1}}$. Assuming a uniform field, what is the value of the gravitational field strength in the region between the planet's surface and P?

A $0.80\,\mathrm{N\,kg^{-1}}$

B $1.25\,\mathrm{N\,kg^{-1}}$

C $8.0\,\mathrm{N\,kg^{-1}}$

D $80\,\mathrm{N\,kg^{-1}}$

11 An artificial satellite of mass m is in a stable circular orbit of radius r around a planet of mass M. Which one of the following expressions gives the speed of the satellite?
G is the universal gravitational constant.

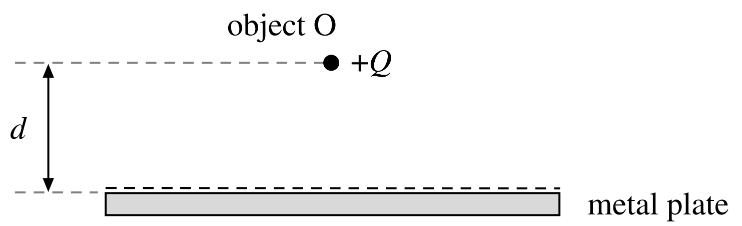
A $\left(\dfrac{Gm}{r}\right)^{\frac{1}{2}}$

B $\left(\dfrac{GM}{r}\right)^{\frac{1}{2}}$

C $\dfrac{Gm}{r}$

D $\left(\dfrac{Gm}{r}\right)^{\frac{3}{2}}$

12 A small object O carrying a charge $+Q$ is placed at a distance d from a metal plate that has an equal and opposite charge. The object is acted on by an electrostatic force F.



Which one of the following expressions has the same unit as F?

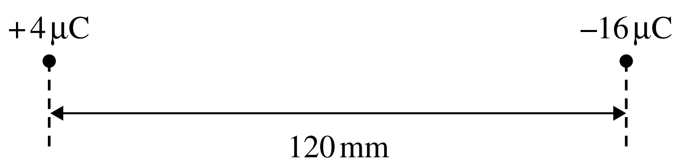
A $\dfrac{\varepsilon_0 Q^2}{d}$

B $\dfrac{\varepsilon_0 Q^2}{d^2}$

C $\dfrac{Q^2}{\varepsilon_0 d}$

D $\dfrac{Q^2}{\varepsilon_0 d^2}$

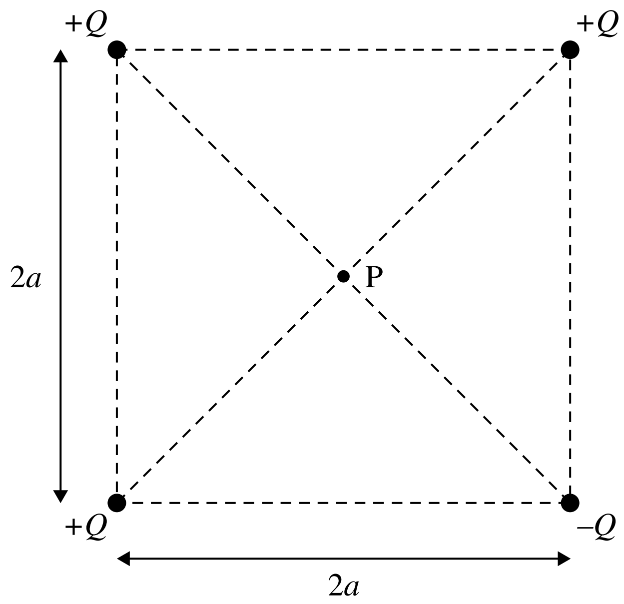
13



The diagram shows two charges, $+4\,\mu C$ and $-16\,\mu C$, 120 mm apart. What is the distance from the $+4\,\mu C$ charge to the point between the two charges where the resultant electric potential is zero?

A 24 mm
B 40 mm
C 80 mm
D 96 mm

14 The diagram shows four point charges at the corners of a square of side $2a$. What is the electric potential at P, the centre of the square?



A $\dfrac{Q}{2\sqrt{2}\pi\varepsilon_0 a}$

B $\dfrac{Q}{\sqrt{2}\pi\varepsilon_0 a}$

C $\dfrac{Q}{2\pi\varepsilon_0 a}$

D $\dfrac{Q}{4\pi\varepsilon_0 a}$

15 A 1 μF capacitor is charged using a **constant** current of 10 μA for 20 s. What is the energy finally stored by the capacitor?

A 2×10^{-3} J

B 2×10^{-2} J

C 4×10^{-2} J

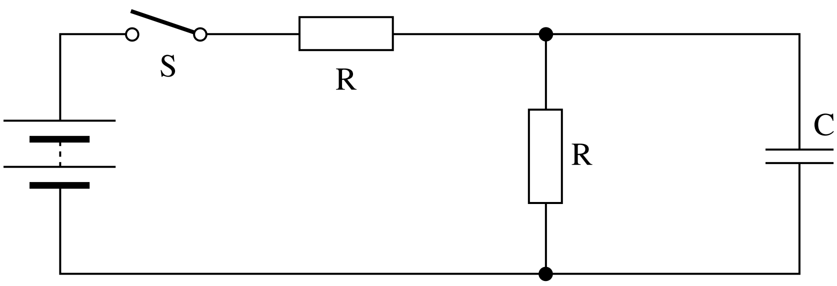
D 4×10^{-1} J

16 A 2.0 mF capacitor, used as the backup for a memory unit, has a potential difference of 5.0 V across it when fully charged. The capacitor is required to supply a constant current of 1.0 μA and can be used until the potential difference across it falls by 10%. How long can the capacitor be used for before it must be recharged?

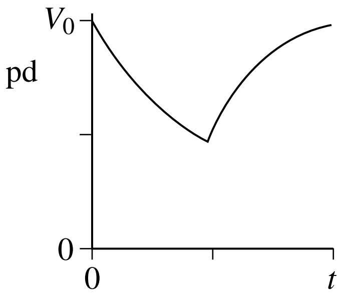
A 10 s
B 100 s
C 200 s
D 1000 s

Turn over ►

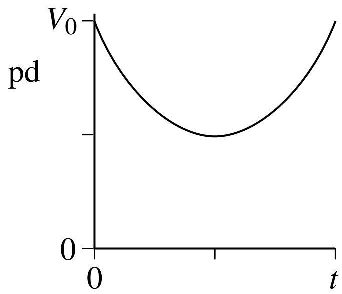
17 When switch S in the circuit is closed, the capacitor C is charged by the battery to a pd V_0. The switch is then opened until the capacitor pd decreases to 0.5 V_0, at which time S is closed again. The capacitor then charges back to V_0.



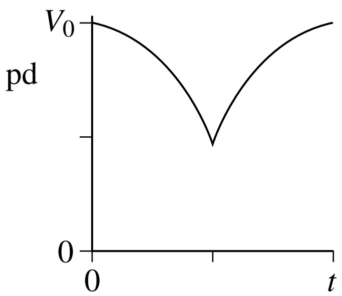
Which graph best shows how the pd across the capacitor varies with time, t, after S is opened?



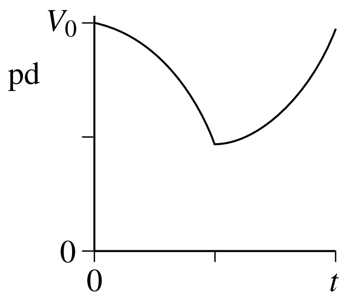
A



B



C

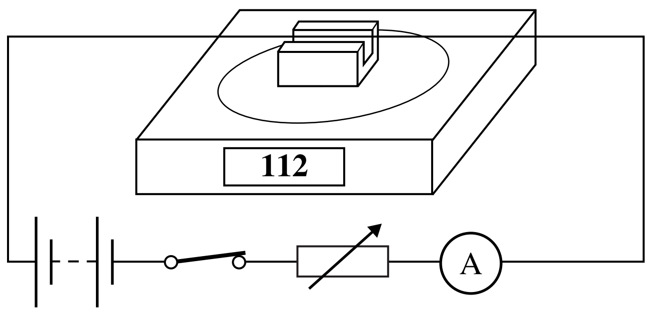


D

18 When a capacitor discharges through a resistor it loses 50% of its charge in 10 s. What is the time constant of the capacitor-resistor circuit?

A 0.5 s
B 5 s
C 14 s
D 17 s

19 The diagram shows a rigidly-clamped straight horizontal current-carrying wire held mid-way between the poles of a magnet on a top pan balance. The wire is perpendicular to the magnetic field direction.



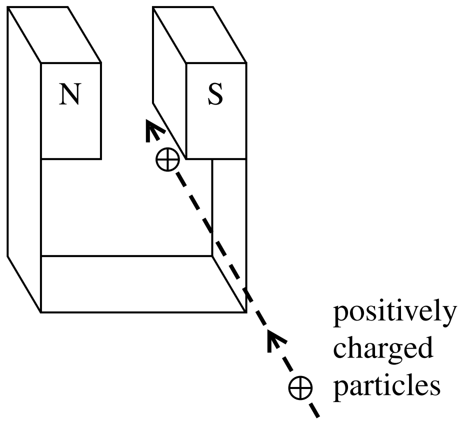
The balance, which was zeroed before the switch was closed, reads 112 g after the switch is closed. If the current is reversed and doubled, what will be the new reading on the balance?

A –224 g
B –112 g
C zero
D 224 g

20 An electron moving with a constant speed enters a uniform magnetic field in a direction at right angles to the field. What is the subsequent path of the electron?

A A straight line in the direction of the field.
B A straight line in a direction opposite to that of the field.
C A circular arc in a plane perpendicular to the direction of the field.
D An elliptical arc in a plane perpendicular to the direction of the field.

21 A jet of air carrying positively charged particles is directed horizontally between the poles of a strong magnet, as shown in the diagram.



In which direction are the charged particles deflected?

A upwards
B downwards
C towards the N pole of the magnet
D towards the S pole of the magnet

22 Which one of the following could **not** be used as a unit of force?

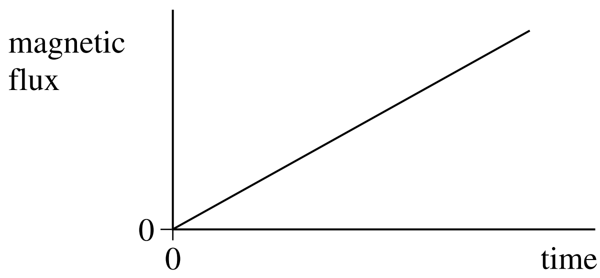
A A T m

B $\mathrm{W\,s^{-2}}$

C $\mathrm{kg\,m\,s^{-2}}$

D $\mathrm{J\,m^{-1}}$

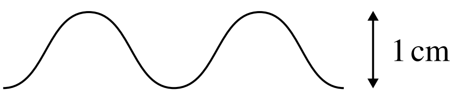
23 The graph shows how the magnetic flux passing through a loop of wire changes with time.



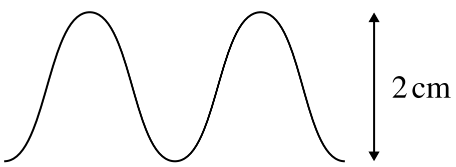
What feature of the graph represents the magnitude of the emf induced in the coil?

A the area enclosed between the graph line and the time axis
B the area enclosed between the graph line and the magnetic flux axis
C the inverse of the gradient of the graph
D the gradient of the graph

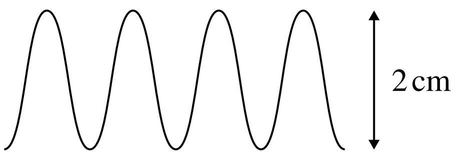
24 A coil rotating in a magnetic field produces the following voltage waveform when connected to an oscilloscope.



With the same oscilloscope settings, which one of the following voltage waveforms would be produced if the coil were rotated at twice the original speed?

A


B


C


D


25 A 230 V, 60 W lamp is connected to the output terminals of a transformer which has a 200 turn primary coil and a 2000 turn secondary coil. The primary coil is connected to an ac source with a variable output pd. The lamp lights at its normal brightness when the primary coil is supplied with an alternating current of 2.7 A.

What is the percentage efficiency of the transformer?

A 3%

B 10%

C 97%

D 100%

END OF QUESTIONS

Centre Number						Candidate Number				
Surname										
Other Names										
Candidate Signature										

For Examiner's Use	
Examiner's Initials	
Question	Mark
1	
2	
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4	
5	
TOTAL	

General Certificate of Education
Advanced Level Examination
June 2010

Physics A PHYA4/2

Unit 4 Fields and Further Mechanics
Section B

Friday 18 June 2010 9.00 am to 10.45 am

For this paper you must have:
- a calculator
- a ruler
- a Data and Formulae Booklet.

Time allowed
- The total time for both sections of this paper is 1 hour 45 minutes. You are advised to spend approximately one hour on this section.

Instructions
- Use black ink or black ball-point pen.
- Fill in the boxes at the top of this page.
- Answer **all** questions.
- You must answer the questions in the spaces provided. Answers written in margins or on blank pages will not be marked.
- Do all rough work in this book. Cross through any work you do not want to be marked.

Information
- The marks for questions are shown in brackets.
- The maximum mark for this section is 50.
- You are expected to use a calculator where appropriate.
- A *Data and Formulae Booklet* is provided as a loose insert.
- You will be marked on your ability to:
  – use good English
  – organise information clearly
  – use specialist vocabulary where appropriate.

Answer **all** questions.

You are advised to spend approximately **one hour** on this section.

1 (a) State Newton's law of gravitation.

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(2 marks)

1 (b) In 1798 Cavendish investigated Newton's law by measuring the gravitational force between two unequal uniform lead spheres. The radius of the larger sphere was 100 mm and that of the smaller sphere was 25 mm.

1 (b) (i) The mass of the smaller sphere was 0.74 kg. Show that the mass of the larger sphere was about 47 kg.

density of lead = 11.3×10^3 kg m^{-3}

(2 marks)

1 (b) (ii) Calculate the gravitational force between the spheres when their surfaces were in contact.

answer = ... N

(2 marks)

Do not write outside the box

1 (c) Modifications, such as increasing the size of each sphere to produce a greater force between them, were considered in order to improve the accuracy of Cavendish's experiment. Describe and explain the effect on the calculations in part (b) of doubling the radius of both spheres.

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(4 marks)

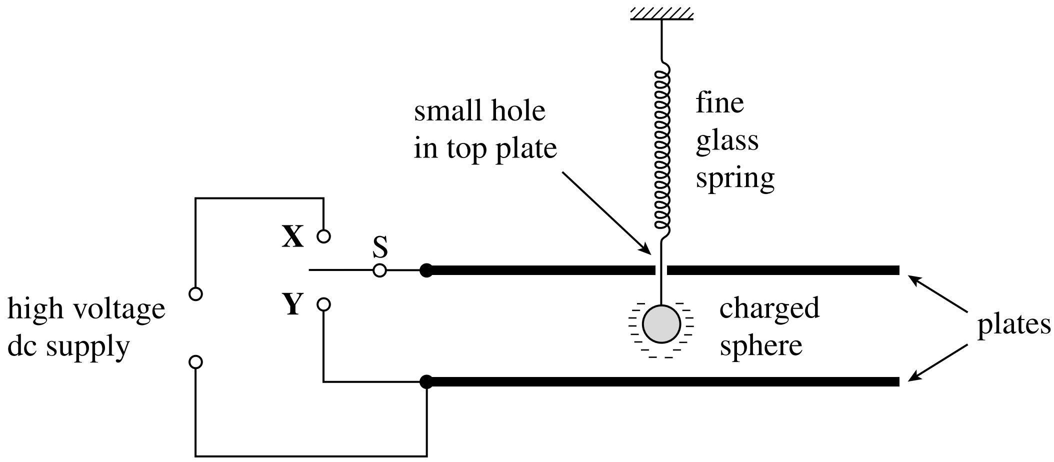
10

Turn over for the next question

Do not write outside the box

2 A small negatively charged sphere is suspended from a fine glass spring between parallel horizontal metal plates, as shown in **Figure 1**.

Figure 1



2 (a) Initially the plates are uncharged. When switch S is set to position **X**, a high voltage dc supply is connected across the plates. This causes the sphere to move vertically upwards so that eventually it comes to rest 18 mm higher than its original position.

2 (a) (i) State the direction of the electric field between the plates.

....

(1 mark)

2 (a) (ii) The spring constant of the glass spring is $0.24\,\text{N m}^{-1}$. Show that the force exerted on the sphere by the electric field is 4.3×10^{-3} N.

(1 mark)

Do not write outside the box

2 (a) (iii) The pd applied across the plates is 5.0 kV. If the charge on the sphere is -4.1×10^{-8} C, determine the separation of the plates.

answer = ... m

(3 marks)

2 (b) Switch S is now moved to position **Y**.

2 (b) (i) State and explain the effect of this on the electric field between the plates.

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(2 marks)

2 (b) (ii) With reference to the forces acting on the sphere, explain why it starts to move with simple harmonic motion.

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(3 marks)

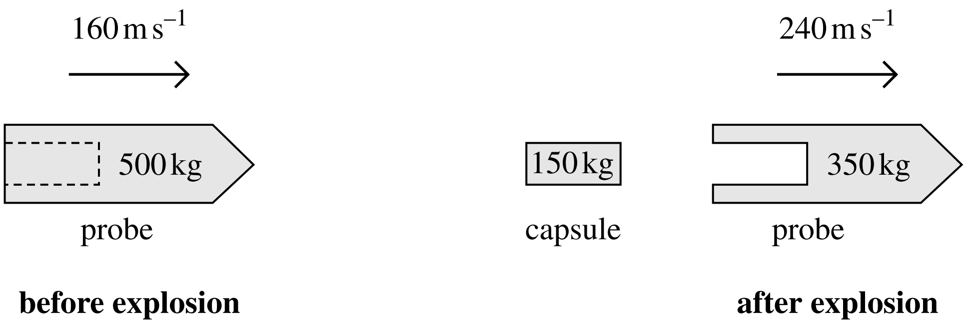
10

Turn over ▶

Do not write outside the box

3 Deep space probes often carry modules which may be ejected from them by an explosion. A space probe of total mass 500 kg is travelling in a straight line through free space at 160 m s^{-1} when it ejects a capsule of mass 150 kg explosively, releasing energy. Immediately after the explosion the probe, now of mass 350 kg, continues to travel in the original straight line but travels at 240 m s^{-1}, as shown in **Figure 2**.

Figure 2



3 (a) Discuss how the principles of conservation of momentum and conservation of energy apply in this instance.

The quality of your written communication will be assessed in this question.

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(6 marks)

3 (b) (i) Calculate the magnitude of the velocity of the capsule immediately after the explosion and state its direction of movement.

magnitude of velocity = ... $m\,s^{-1}$

direction of movement ....

(3 marks)

3 (b) (ii) Determine the total amount of energy given to the probe and capsule by the explosion.

answer = ... J

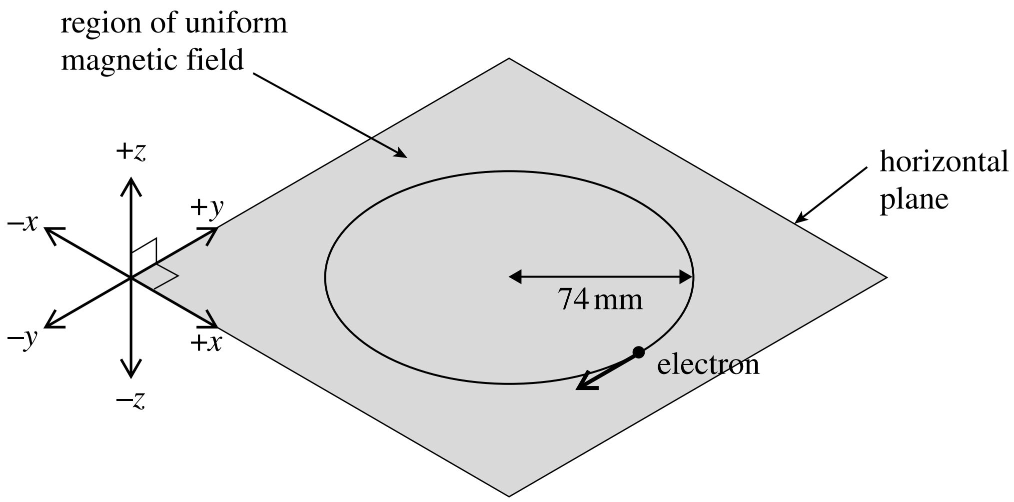
(4 marks)

13

Turn over for the next question

4 When travelling in a vacuum through a uniform magnetic field of flux density 0.43 mT, an electron moves at constant speed in a horizontal circle of radius 74 mm, as shown in **Figure 3**.

Figure 3



4 (a) When viewed from vertically above, the electron moves clockwise around the horizontal circle. In which one of the six directions shown on **Figure 3**, +x, –x, +y, –y, +z or –z, is the magnetic field directed?

direction of magnetic field ....

(1 mark)

4 (b) Explain why the electron is accelerating even though it is travelling at constant speed.

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(2 marks)

Do not write outside the box

4 (c) (i) By considering the centripetal force acting on the electron, show that its speed is $5.6 \times 10^6\,\mathrm{m\,s^{-1}}$.

(2 marks)

4 (c) (ii) Calculate the angular speed of the electron, giving an appropriate unit.

answer = ...

(2 marks)

4 (c) (iii) How many times does the electron travel around the circle in one minute?

answer = ...

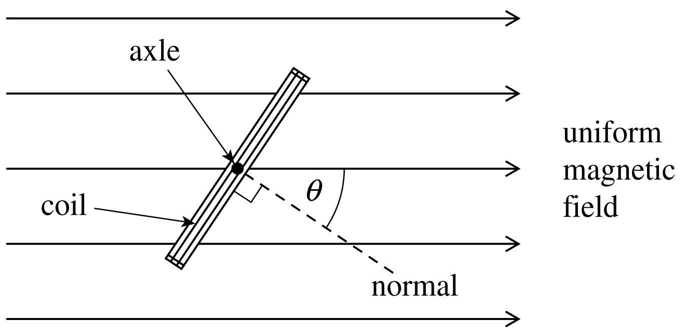
(2 marks)

9

Turn over ▶

5 **Figure 4** shows an end view of a simple electrical generator. A rectangular coil is rotated in a uniform magnetic field with the axle at right angles to the field direction. When in the position shown in **Figure 4** the angle between the direction of the magnetic field and the normal to the plane of the coil is θ.

Figure 4



5 (a) The coil has 50 turns and an area of $1.9 \times 10^{-3}\,\text{m}^2$. The flux density of the magnetic field is $2.8 \times 10^{-2}\,\text{T}$. Calculate the flux linkage for the coil when θ is 35°, expressing your answer to an appropriate number of significant figures.

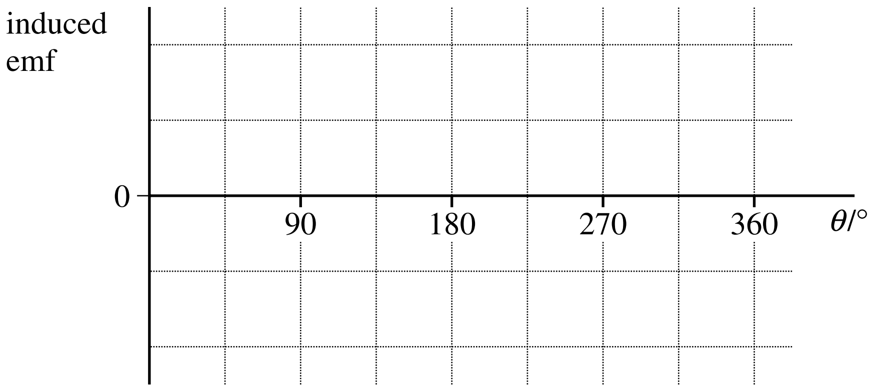
answer = ... Wb turns

(3 marks)

5 (b) The coil is rotated at constant speed, causing an emf to be induced.

5 (b) (i) Sketch a graph on the outline axes to show how the induced emf varies with angle θ during one complete rotation of the coil, starting when $\theta = 0$. Values are not required on the emf axis of the graph.

(1 mark)



5 (b) (ii) Give the value of the flux linkage for the coil at the positions where the emf has its greatest values.

answer = ... Wb turns

(1 mark)

5 (b) (iii) Explain why the magnitude of the emf is greatest at the values of θ shown in your answer to part (b)(i).

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(3 marks)

8

END OF QUESTIONS

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ANSWER IN THE SPACES PROVIDED

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Advanced Level Examination
June 2010

Physics A PHYA4

Unit 4 Fields and Further Mechanics

Data and Formulae Booklet

DATA
FUNDAMENTAL CONSTANTS AND VALUES

Quantity	*Symbol*	*Value*	*Units*
speed of light in vacuo	c	3.00×10^{8}	m s^{-1}
permeability of free space	μ_o	$4\pi \times 10^{-7}$	H m^{-1}
permittivity of free space	ε_o	8.85×10^{-12}	F m^{-1}
charge of electron	e	-1.60×10^{-19}	C
the Planck constant	h	6.63×10^{-34}	J s
gravitational constant	G	6.67×10^{-11}	N m^{2} kg^{-2}
the Avogadro constant	N_A	6.02×10^{23}	mol^{-1}
molar gas constant	R	8.31	J K^{-1} mol^{-1}
the Boltzmann constant	k	1.38×10^{-23}	J K^{-1}
the Stefan constant	σ	5.67×10^{-8}	W m^{-2} K^{-4}
the Wien constant	α	2.90×10^{-3}	m K
electron rest mass (equivalent to 5.5×10^{-4} u)	m_e	9.11×10^{-31}	kg
electron charge/mass ratio	e/m_e	1.76×10^{11}	C kg^{-1}
proton rest mass (equivalent to 1.00728 u)	m_p	$1.67(3) \times 10^{-27}$	kg
proton charge/mass ratio	e/m_p	9.58×10^{7}	C kg^{-1}
neutron rest mass (equivalent to 1.00867 u)	m_n	$1.67(5) \times 10^{-27}$	kg
gravitational field strength	g	9.81	N kg^{-1}
acceleration due to gravity	g	9.81	m s^{-2}
atomic mass unit (1u is equivalent to 931.3 MeV)	u	1.661×10^{-27}	kg

ASTRONOMICAL DATA

Body	*Mass/kg*	*Mean radius/m*
Sun	1.99×10^{30}	6.96×10^{8}
Earth	5.98×10^{24}	6.37×10^{6}

GEOMETRICAL EQUATIONS

arc length	$= r\theta$
circumference of circle	$= 2\pi r$
area of circle	$= \pi r^2$
surface area of cylinder	$= 2\pi rh$
volume of cylinder	$= \pi r^2 h$
area of sphere	$= 4\pi r^2$
volume of sphere	$= \dfrac{4}{3}\pi r^3$

This insert page should **not** be sent to the examiner

AS FORMULAE

PARTICLE PHYSICS

Rest energy values

class	*name*	*symbol*	*rest energy /MeV*
photon	photon	γ	0
lepton	neutrino	ν_e	0
		ν_μ	0
	electron	$e^\pm$	0.510999
	muon	$\mu^\pm$	105.659
mesons	π meson	$\pi^\pm$	139.576
		π^0	134.972
	K meson	$K^\pm$	493.821
		K^0	497.762
baryons	proton	p	938.257
	neutron	n	939.551

Properties of quarks
antiquarks have opposite signs

type	*charge*	*baryon number*	*strangeness*
u	$+\frac{2}{3}e$	$+\frac{1}{3}$	0
d	$-\frac{1}{3}e$	$+\frac{1}{3}$	0
s	$-\frac{1}{3}e$	$+\frac{1}{3}$	-1

Properties of Leptons

	lepton number
particles: $e^-, \nu_e ; \mu^-, \nu_\mu$	+1
antiparticles: $e^+, \overline{\nu_e} ; \mu^+, \overline{\nu_\mu}$	–1

Photons and Energy Levels

photon energy $E = hf = hc/\lambda$

photoelectricity $hf = \phi + E_{K\,(max)}$

energy levels $hf = E_1 - E_2$

de Broglie Wavelength $\lambda = \frac{h}{p} = \frac{h}{mv}$

ELECTRICITY

current and pd $I = \frac{\Delta Q}{\Delta t}$ $V = \frac{W}{Q}$ $R = \frac{V}{I}$

emf $\varepsilon = \frac{E}{Q}$ $\varepsilon = I(R + r)$

resistors in series $R = R_1 + R_2 + R_3 + \ldots$

resistors in parallel $\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + \ldots$

resistivity $\rho = \frac{RA}{L}$

power $P = VI = I^2R = \frac{V^2}{R}$

alternating current $I_{rms} = \frac{I_0}{\sqrt{2}}$ $V_{rms} = \frac{V_0}{\sqrt{2}}$

MECHANICS

moments moment $= Fd$

velocity and acceleration $v = \frac{\Delta s}{\Delta t}$ $a = \frac{\Delta v}{\Delta t}$

equations of motion $v = u + at$ $s = \frac{(u+v)}{2}t$

$v^2 = u^2 + 2as$ $s = ut + \frac{at^2}{2}$

force $F = ma$

work, energy and power $W = Fs\cos\theta$

$E_K = ½\, m v^2$ $\Delta E_P = mg\Delta h$

$P = \frac{\Delta W}{\Delta t}$, $P = Fv$

efficiency $= \frac{\text{useful output power}}{\text{input power}}$

MATERIALS

density $\rho = \frac{m}{V}$ Hooke's law $F = k\,\Delta L$

Young modulus $= \frac{\text{tensile stress}}{\text{tensile strain}}$ tensile stress $= \frac{F}{A}$

tensile strain $= \frac{\Delta L}{L}$

energy stored $E = \frac{1}{2}F\Delta L$

WAVES

wave speed $c = f\lambda$ *period* $T = \frac{1}{f}$

fringe spacing $w = \frac{\lambda D}{s}$ *diffraction grating* $d\sin\theta = n\lambda$

refractive index of a substance s, $n = \frac{c}{c_s}$

for two different substances of refractive indices n_1 and n_2,

law of refraction $n_1 \sin\theta_1 = n_2 \sin\theta_2$

critical angle $\sin\theta_c = \frac{n_2}{n_1}$ for $n_1 > n_2$

A2 FORMULAE

MOMENTUM

force $F = \dfrac{\Delta(mv)}{\Delta t}$

impulse $F\,\Delta t = \Delta(mv)$

CIRCULAR MOTION

angular velocity $\omega = \dfrac{v}{r}$

$\omega = 2\pi f$

centripetal acceleration $a = \dfrac{v^2}{r} = \omega^2 r$

centripetal force $F = \dfrac{mv^2}{r} = m\omega^2 r$

OSCILLATIONS

acceleration $a = -(2\pi f)^2 x$

displacement $x = A\cos(2\pi f t)$

speed $v = \pm 2\pi f\sqrt{A^2 - x^2}$

maximum speed $v_{max} = 2\pi f A$

maximum acceleration $a_{max} = (2\pi f)^2 A$

for a mass-spring system $T = 2\pi\sqrt{\dfrac{m}{k}}$

for a simple pendulum $T = 2\pi\sqrt{\dfrac{l}{g}}$

GRAVITATIONAL FIELDS

force between two masses $F = \dfrac{G m_1 m_2}{r^2}$

gravitational field strength $g = \dfrac{F}{m}$

magnitude of gravitational field strength in a radial field $g = \dfrac{GM}{r^2}$

gravitational potential $\Delta W = m\Delta V$

$V = -\dfrac{GM}{r}$

$g = -\dfrac{\Delta V}{\Delta r}$

ELECTRIC FIELDS AND CAPACITORS

force between two point charges $F = \dfrac{1}{4\pi\varepsilon_0}\dfrac{Q_1 Q_2}{r^2}$

force on a charge $F = EQ$

field strength for a uniform field $E = \dfrac{V}{d}$

field strength for a radial field $E = \dfrac{Q}{4\pi\varepsilon_0 r^2}$

electric potential $\Delta W = Q\Delta V$

$V = \dfrac{1}{4\pi\varepsilon_0}\dfrac{Q}{r}$

capacitance $C = \dfrac{Q}{V}$

decay of charge $Q = Q_0 e^{-t/RC}$

time constant RC

capacitor energy stored $E = \dfrac{1}{2}QV \;= \dfrac{1}{2}CV^2 \;= \dfrac{1}{2}\dfrac{Q^2}{C}$

MAGNETIC FIELDS

force on a current $F = BIl$

force on a moving charge $F = BQv$

magnetic flux $\Phi = BA$

magnetic flux linkage $N\Phi = BAN$

magnitude of induced emf $\varepsilon = N\dfrac{\Delta\Phi}{\Delta t}$

emf induced in a rotating coil $N\Phi = BAN\cos\theta$

$\varepsilon = BAN\omega\sin\omega t$

transformer equations $\dfrac{N_s}{N_p} = \dfrac{V_s}{V_p}$

efficiency $= \dfrac{I_s V_s}{I_p V_p}$

RADIOACTIVITY AND NUCLEAR PHYSICS

the inverse square law for γ radiation $I = \dfrac{k}{x^2}$

radioactive decay $\dfrac{\Delta N}{\Delta t} = -\lambda N,\; N = N_o e^{-\lambda t}$

activity $A = \lambda N$

half-life $T_{½} = \dfrac{\ln 2}{\lambda}$

nuclear radius $R = r_0 A^{1/3}$

energy-mass equation $E = mc^2$

GASES AND THERMAL PHYSICS

gas law $pV = nRT$

$pV = NkT$

kinetic theory model $pV = \dfrac{1}{3}Nm(c_{rms})^2$

kinetic energy of gas molecule $\dfrac{1}{2}m(c_{rms})^2 = \dfrac{3}{2}kT = \dfrac{3RT}{2N_A}$

energy to change temperature $Q = mc\Delta T$

energy to change state $Q = ml$

OPTIONS FORMULAE

ASTROPHYSICS

1 astronomical unit = 1.50×10^{11} m
1 light year = 9.46×10^{15} m
1 parsec = 206265 AU = 3.08×10^{16} m = 3.261yr
Hubble constant, H = 65 km s^{-1} Mpc^{-1}

lens equation $\frac{1}{f} = \frac{1}{u} + \frac{1}{v}$

$M = \dfrac{\text{angle subtended by image at eye}}{\text{angle subtended by object at unaided eye}}$

in normal adjustment $M = \dfrac{f_0}{f_e}$

resolving power $\theta \approx \dfrac{\lambda}{D}$

magnitude equation $m - M = 5 \log \dfrac{d}{10}$

Wien's law $\lambda_{max} T = 0.0029$ m K

Hubble law $v = H d$

Stefan's law $P = \sigma A T^4$

Doppler shift for v << c $z = \dfrac{\Delta f}{f} = -\dfrac{\Delta\lambda}{\lambda} = \dfrac{v}{c}$

Schwarzschild radius $R_s = \dfrac{2GM}{c^2}$

MEDICAL PHYSICS

lens equations $P = \dfrac{1}{f}$

$m = \dfrac{v}{u}$

$\dfrac{1}{f} = \dfrac{1}{u} + \dfrac{1}{v}$

intensity level intensity level $= 10 \log \dfrac{I}{I_0}$

absorption $I = I_0 e^{-\mu x}$

$\mu_m = \dfrac{\mu}{\rho}$

APPLIED PHYSICS

moment of inertia $I = \Sigma mr^2$

angular kinetic energy $E_k = \dfrac{1}{2} I\omega^2$

equations of angular motion

$\omega_2 = \omega_1 + \alpha t$

$\omega_2^2 = \omega_1^2 + 2\alpha\theta$

$\theta = \omega_1 t + \dfrac{1}{2}\alpha t^2$

$\theta = ½ (\omega_1 + \omega_2) t$

torque $T = I \alpha$

angular momentum angular momentum = $I\omega$

work done $W = T\theta$

power $P = T\omega$

thermodynamics $Q = \Delta U + W$

$W = p\Delta V$

adiabatic change pV^γ = constant

isothermal change pV = constant

heat engines

efficiency = $\dfrac{W}{Q_{in}} = \dfrac{Q_{in} - Q_{out}}{Q_{in}}$

maximum efficiency = $\dfrac{T_H - T_C}{T_H}$

work done per cycle = area of loop

input power = calorific value × fuel flow rate

indicated power = (area of p-V loop) × (no of cycles per second) × number of cylinders

output of brake power $P = T\omega$

friction power = indicated power – brake power

heat pumps and refrigerators

refrigerator: $COP_{ref} = \dfrac{Q_{out}}{W} = \dfrac{Q_{out}}{Q_{in} - Q_{out}}$

heat pump: $COP_{hp} = \dfrac{Q_{in}}{W} = \dfrac{Q_{in}}{Q_{in} - Q_{out}}$

TURNING POINTS IN PHYSICS

electrons in fields $F = \dfrac{eV}{d}$

$F = Bev$

$r = \dfrac{mv}{Be}$

$½ mv^2 = eV$

$\dfrac{QV}{d} = mg$

$F = 6\pi \eta r v$

wave particle duality $c = \dfrac{1}{\sqrt{\mu_0 \varepsilon_0}}$

$\lambda = \dfrac{h}{p} = \dfrac{h}{\sqrt{2meV}}$

special relativity $E = mc^2 = \dfrac{m_0 c^2}{\left(1 - \dfrac{v^2}{c^2}\right)^{\frac{1}{2}}}$

$l = l_0 \left(1 - \dfrac{v^2}{c^2}\right)^{\frac{1}{2}}$ $\quad t = t_0 \left(1 - \dfrac{v^2}{c^2}\right)^{-\frac{1}{2}}$