OCR
RECOGNISING ACHIEVEMENT

SPECIMEN

Advanced GCE

PHYSICS A

Unit G484:The Newtonian World

Specimen Paper

G484 QP

Candidates answer on the question paper.
Additional Materials:
Data and Formulae sheet
Electronic calculator

Time: 1 hour

Candidate Name

Centre Number

Candidate Number

INSTRUCTIONS TO CANDIDATES

- Write your name, Centre number and Candidate number in the boxes above.
- Answer **all** the questions.
- Use blue or black ink. Pencil may be used for graphs and diagrams only.
- Read each question carefully and make sure you know what you have to do before starting your answer.
- Do **not** write in the bar code.
- Do **not** write outside the box bordering each page.
- WRITE YOUR ANSWER TO EACH QUESTION IN THE SPACE PROVIDED.

INFORMATION FOR CANDIDATES

- The number of marks is given in brackets [] at the end of each question or part question.
- ✎ Where you see this icon you will be awarded marks for the quality of written communication in your answer.
- You may use an electronic calculator.
- You are advised to show all the steps in any calculations.
- The total number of marks for this paper is **60**.

FOR EXAMINER'S USE		
Qu.	**Max.**	**Mark**
1	13	
2	15	
3	10	
4	14	
5	8	
TOTAL	**60**	

This document consists of **11** printed pages and **1** blank page.

SP (SLM) T12103

[Turn Over

Answer **all** the questions.

1 **(a)** State Newton's second law of motion.

....

.... **[2]**

(b) Explain how the principle of conservation of momentum is a natural consequence of Newton's laws of motion.

....

....

....

.... **[3]**

(c)

Most cars are now fitted with safety airbags. During a sudden impact, a triggering mechanism fires an ammunition cartridge that rapidly releases nitrogen gas into the airbag.

In a particular simulated accident, a car of mass 800 kg is travelling towards a wall. Just before impact, the speed of the car is 32 m s^{-1}. It rebounds at two-thirds of its initial speed. The car takes 0.50 s for the car to come to rest. During the crash, the car's airbag fills up to a maximum volume of 3.4×10^{-2} m^3 at a pressure of 1.0×10^5 Pa. The temperature inside the airbag is 20 ^{0}C. Calculate:

(i) the change in the momentum of the car

momentum change = ... **[2]**

(ii) the magnitude and direction of the average force acting on the car during impact.

force = ... N **[2]**

direction:... **[1]**

(iii) the mass of nitrogen inside the cartridge.

Molar mass of nitrogen = 0.014 kg mol^{-1}

mass = ... kg **[3]**

[Total: 13]

2 **(a)** Define *gravitational field strength* at a point in a gravitational field.

....

.... **[1]**

(b) A satellite of mass 1500 kg is launched from the surface of the Earth into a circular orbit around the Earth at a height of 6800 km above the Earth's surface. At this height the satellite has an orbital period of 8.5×10^3 s. The radius of the Earth is 6400 km.

(i) A student uses the equation

gain in potential energy = mgh

to determine the increase in the potential energy of the satellite. Suggest why this equation **cannot** be used and state whether the student's answer would be less than, equal to, or greater than the actual value.

....

....

.... **[2]**

(ii) Calculate the kinetic energy of the satellite.

kinetic energy = ... J **[3]**

(iii) State a benefit of having a satellite in a geostationary orbit round the Earth. Explain whether or not a satellite orbiting at a height of 6800 km above the Earth's surface is in a geostationary orbit.

✎ *In your answer, you should use appropriate technical terms, spelled correctly.*

....

....

....

....

.... **[3]**

(c) Fig. 2.1 shows how the gravitational field strength *g* varies with distance *r* from the **centre** of a planet of radius 2.0×10^7 m.

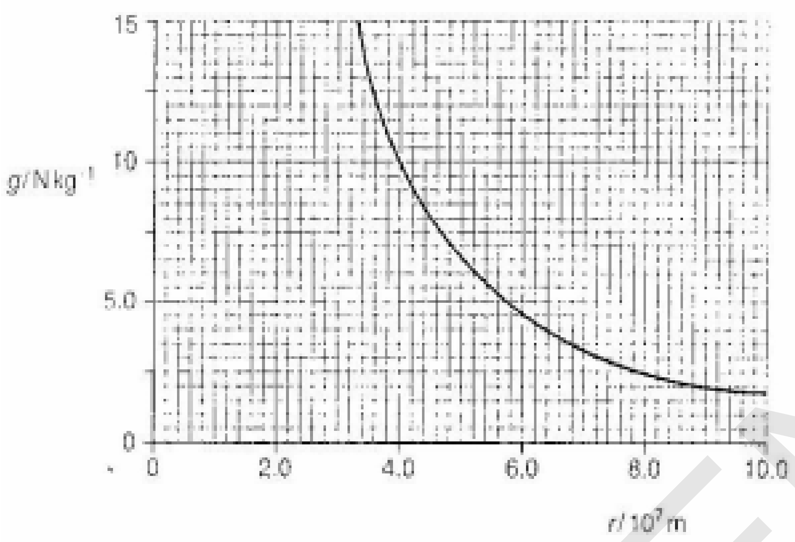

Fig. 2.1

The gravitational field strength on the surface of the planet is 40 N kg^{-1}.

(i) Use Fig. 2.1 to write down the value for *g* at a height of 4.0×10^7 m above the **surface** of the planet.

g = ...N kg^{-1} **[2]**

(ii) Calculate the mass *M* of the planet. Assume that the planet can be treated as a point mass of magnitude *M* situated at its centre.

M =. .... kg **[2]**

(iii) Astronomers investigating the planet believe that the planet's interior has a uniform density. Show that within the interior of the planet, its gravitational field strength *g* is proportional to the distance *r* from the centre.

.... **[2]**

[Total: 15]

[Turn over

3 **(a)** Define *simple harmonic motion*.

✐ *In your answer, you should use appropriate technical terms, spelled correctly.*

....

.... **[2]**

(b) Fig. 3.1 shows a trolley attached to the end of a helical spring. The trolley executes simple harmonic motion on the smooth table.

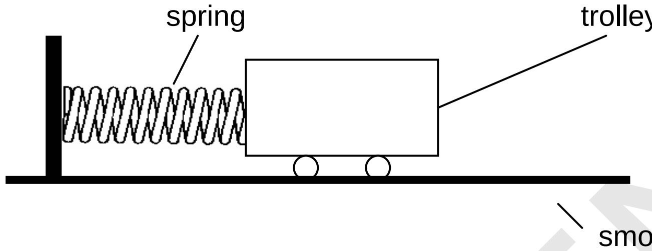

Fig. 3.1

(i) Describe how, for this oscillating trolley, you can determine the following quantities using a stopwatch and a ruler.

1 the frequency oscillation

....

.... **[2]**

2 the maximum speed of the trolley

....

.... **[2]**

(ii) The amplitude of the trolley is doubled. The trolley still moves in simple harmonic motion. State with a reason the change, if any, in the maximum speed of the trolley.

....

....

.... **[2]**

(iii) Using your knowledge of Hooke's law and Newton's second law, determine the period T of the trolley in terms of the force constant k of the spring and the mass m of the trolley.

....

....

....

.... **[3]**

[Total: 10]

4 **(a)** **(i)** Explain the term *internal energy*.

....

.... … **[2]**

(ii) Define *specific heat capacity of a substance*.

....

.... … **[1]**

(b) Consider a 2.0 kg block of aluminium. Assume that the heat capacity of aluminium is independent of temperature and that the internal energy is zero at absolute zero. Also assume that the volume of the block does not change over the range of temperature from 0 K to 293 K. The specific heat capacity of aluminium is 920 J kg^{-1} K^{-1}.

(i) Show that the internal energy of this block at 20 ^{o}C is 540 kJ.

[2]

(ii) Hence show that the mean internal kinetic energy per atom in the 2.0 kg aluminium block at 20 ^{o}C is about 1.2×10^{-20} J.

The molar mass of aluminium is 0.027 kg mol^{-1}.

[3]

(iii) In 1819, Dulong and Petit measured the specific heat capacities of bodies made from different substances and found that for one mole of each substance, the molar heat capacity was about 25 J mol^{-1} K^{-1}. Use the data from either **(i)** or **(ii)** to show that this is true for aluminium.

[2]

[Turn over

(c) A student performs an experiment to measure the specific heat capacity of a 1kg aluminium block using the apparatus shown in Fig 4.1.

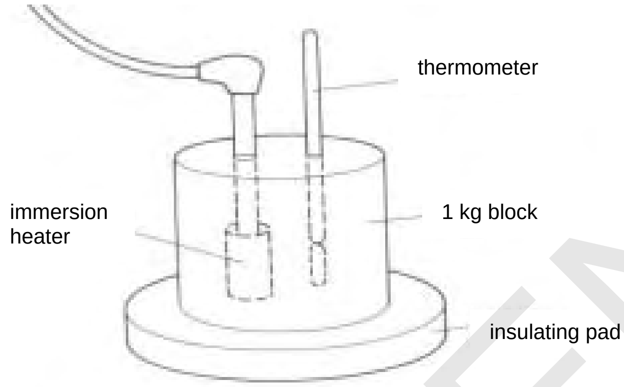

Fig 4.1

He heats the block using a 50W electrical heater. Using the value for aluminium from a data book, he predicts the time to heat the block from 20°C to 30°C, to be 3.1 minutes. He heats the block for this time but finds that the temperature of the block continues to rise after he switches the heater off. He also finds that the highest temperature reached is only 9.1°C.

Explain his observations and why he does not obtain the data book value of 920J kg^{-1} K^{-1}. **[4]**

5 **(a)** State any two assumptions of the kinetic theory of gases.

....

....

.... **[2]**

(b) The atoms on the surface of a hot star may be treated as an ideal gas. Ideal gases obey the kinetic theory of gases. The interior of a particular star has a core temperature of 10^9 K and its surface temperature is 4000 K. For the hydrogen atoms of this star, calculate the ratio:

$$\text{ratio} = \frac{\text{average speed of atoms in the core}}{\text{average speed of atoms on the surface}}$$

ratio = ... **[2]**

(c) Suggest why the hydrogen atoms on the surface of the star do not all have the same speed.

....

.... **[1]**

(d) The emission spectrum of hydrogen gas atoms shows a strong red light of wavelength 656.3 nm. The motion of the atoms on the surface of the star in **(b)** causes *spectral broadening* of this line due to an effect known as the Doppler effect. The wavelength of light becomes longer when the hydrogen atoms on the surface of the star are moving away from our line of sight and shorter when they are moving towards us. This wavelength λ of the spectral line is broadened by an amount $\Delta\lambda$. Astronomers use the equation below to determine the surface temperature T in kelvins (K) of a star:

$$\frac{\Delta\lambda}{\lambda} = \sqrt{\frac{2kT}{mc^2}}$$

where k is the Boltzmann factor, m is the mass of the hydrogen atom and c is the speed of light in a vacuum.

(i) Calculate the spectral broadening $\Delta\lambda$ for the 656.3 nm line emitted from the star in **(b)**.

$\Delta\lambda$ = ...nm **[2]**

(ii) Suggest why the spectral lines from heavier atoms, such as carbon, show very little broadening.

....**[1]**

[Total: 8]

Paper Total [60]

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OXFORD CAMBRIDGE AND RSA EXAMINATIONS

Advanced GCE

PHYSICS A G484 MS

Unit G484: The Newtonian World

Specimen Mark Scheme

The maximum mark for this paper is **60**.

Question Number	Answer	Max Mark
1(a)	The (net) force acting on an object is (directly) proportional to the rate of change of momentum and takes place in the direction of the force.	[B2]
(b)	According to Newton's third law: When two objects interact, the force acting on one of objects is equal but opposite to the force acting on the other object.	[B1]
	The time *t* of 'contact' for the objects is the same and since $\Delta p = Ft$,	[B1]
	the gain in momentum for one object is equal to the loss of momentum for the other object.	[B1]
(c)(i)	*u*= 32 (m s^{-1}) *v* = - 2/3 × 32 = - 21.33 (m s^{-1}) *t* = 0.50 s	[C1]
	$\Delta p = 800(-21.33 - 32) = -4.27 \times 10^4$ $\underline{\text{kg m s}^{-1}}$	[A1]
(ii)	$F = \Delta p / \Delta t$ / $F = 4.27 \times 10^4 / 0.50$	[C1]
	$F \approx 8.5 \times 10^4$ (N)	[A1]
	Direction: Opposite to the initial velocity / away from the wall	[B1]
(iii)	$N = pV / kT = (1.0 \times 10^5 \times 3.4 \times 10^{-2}) / (1.38 \times 10^{-23} \times 293)$	[C1]
	$N = 8.41 \times 10^{23}$	[C1]
	mass = $8.41 \times 10^{23} / 6.02 \times 10^{23}) \times 0.014$	
	mass = 0.0196 (kg) ≈ 0.020 kg	[A1]
2(a)	It is the force (of attraction) <u>per</u> unit mass.	[B1]
(b)(i)	The gravitational field strength *g* is not constant.	[B1]
	The student's value would be greater than the actual value (because the average magnitude of *g* is less than 9.81 m s^{-1}).	[B1]
(ii)	KE = $1/2mv^2$	
	$v = 2\pi r / T$	[C1]
	$v = 2 \times \pi \times (6800 + 6400) \times 10^3 / 8.5 \times 10^3$ / *v* = 9.76 × 10^3 (m s^{-1})	[C1]
	KE = $1/2 \times 1500 \times (9.76 \times 10^3)^2$	
	KE = 7.1(4) × 10^{10} (J)	[A1]
(iii)	A geostationary satellite stays above the same point on the Earth and as such can be used for radio communications. (the term *communications* to be included and spelled correctly to gain the mark).	[B1]
	The satellite is not in geostationary orbit	[M1]
	because its period is less than 1 day / 8.6 × 10^4 s.	[A1]
(c)(i)	*r* has been increased by a factor of 3 from the centre of planet.	[C1]
	$g = (40/3^2 =) 4.4(4)$ (N kg^{-1})	[A1]
(ii)	$M = gr^2 / G$	
	$M = (40 \times [2.0 \times 10^7]^2) / 6.67 \times 10^{-11}$	[C1]
	M = 2.4 × 10^{26} (kg)	[A1]
(iii)	$M = \rho V = 4/3\pi r^3 \rho$	[M1]
	$g = GM / r^2 \propto r^3 / r^2$ (Hence $g \propto r$)	[A1]

Question Number	Answer	Max Mark
3(a)	The acceleration of the oscillator is directly proportional to the displacement (the term *displacement* to be included and spelled correctly to gain the mark). with the acceleration always directed to a fixed / equilibrium point	[B1] [B1]
b(i)	1. Measure the time *t* for *N* oscillations. frequency *f* = *N*/*t* 2. Measure the amplitude *A* of the oscillations using the ruler. maximum speed is calculated using: $v_{\max} = (2\pi f)A$	[M1] [A1] [M1] [A1]
(ii)	The maximum speed is doubled because the frequency is the same and $v_{\max} \propto A$	[B1] [B1]
(iii)	$F = (-)\,kx$ and $F = ma$ Therefore $ma = (-)\,kx$ $\omega^2 = k/m$ $T = 2\pi\sqrt{(m/k)}$	[M1] [M1]
4(a)(i)	Internal energy is the total kinetic and potential energies of all the atoms moving randomly within the substance / system / body.	[B1] [B1]
(ii)	Specific heat capacity of a substance is the heat required to change the temperature of a unit mass by 1K / 1°C.	[B1]
(b)(i)	$E = mc\Delta\theta$ / $E = 2.0 \times 920 \times 293$ $E = 5.39 \times 10^5$ (J) $E \approx 540$ kJ	[C1] [A1] [A0]
(ii)	number of moles = $2.0/0.027 (= 74.1)$ number of atoms = $(2.0/0.027)N_A$ / number of atoms $= 4.46 \times 10^{25}$ average energy = $5.39 \times 10^5 / 4.46 \times 10^{25}$ average energy = $1.2(1) \times 10^{-20}$ (J)	[C1] [C1] [C1] [A0]
(iii)	energy per mole per K = $(1.2 \times 10^{-20} \times 6.02 \times 10^{23})/293$ energy per mole per K = 24.7 J mol^{-1} K^{-1}	[C1] [A1]
(c)	Time Delay: The block has to come to a “uniform” temperature. Energy is conducted from heater to block in a finite but short time. Thermometer is a finite distance from heater Maximum Temperature: The surroundings of the block are at room temperature so energy is transferred by conduction, convection and radiation from the block to the surroundings, so the block does not reach the “theoretical” maximum temperature expected.	[2] [2]

Question Number	Answer	Max Mark
5(a)	Any two from: Collisions between atoms is elastic Time between collisions is negligible compared with time of collisions Motion of atoms is random There are a very large number of atoms	[B1×2]
(b)	$1/2mv^2 \propto T$ ratio = $(10^9/4000)^{1/2}$ ratio = 500	[C1] [A1]
(c)	They collide randomly and hence have a range of speeds.	[B1]
(d)(i)	$\Delta\lambda = 656.3 \times \sqrt{(2 \times 1.38 \times 10^{-23} \times 4000 / 1.7 \times 10^{-27} \times [3.0 \times 10^{8}]^{2})}$ $\Delta\lambda \approx 1.8 \times 10^{-2}$ (nm)	[C1] [A1]
(d)(ii)	Carbon atoms are more massive (and $\Delta\lambda \propto$ 1/mass)	[B1]
	Paper Total	**[60]**

Assessment Objectives Grid (includes QWC)

Question	AO1	AO2	AO3	Total
1(a)	2			**2**
1(b)	2	1		**3**
1(c)(i)		2		**2**
1(c)(ii)		3		**3**
1(c)(iii)		3		**3**
2(a)	1			**1**
2(b)(i)	1	1		**2**
2(b)(ii)		3		**3**
2(b)(iii)	2	1		**3**
2(c)(i)		2		**2**
2(c)(ii)		2		**2**
2(c)(iii)		2		**2**
3(a)	2			**2**
3(b)(i)		4		**4**
3(b)(ii)	1	1		**2**
3(b)(iii)		2		**2**
4(a)(i)	2			**2**
4(a)(ii)	1			**1**
4(b)(i)		2		**2**
4(b)(ii)		3		**3**
4(b)(iii)		2		**2**
4(c)			4	**4**
5(a)	2			**2**
5(b)		2		**2**
5(c)	1			**1**
5(d)(i)		2		**2**
5(d)(ii)	1			**1**
Totals	**18**	**37**	**4**	**60**

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