OCR Physics Unit 4

Past Paper Pack

2010-2013

THIS IS A NEW SPECIFICATION

OCR
RECOGNISING ACHIEVEMENT

ADVANCED GCE

PHYSICS A **G484**

The Newtonian World

Candidates answer on the Question Paper

OCR Supplied Materials:
- Data, Formulae and Relationships Booklet

Other Materials Required:
- Electronic calculator

Thursday 28 January 2010
Afternoon

Duration: 1 hour

Candidate Forename		Candidate Surname	

Centre Number						Candidate Number				

INSTRUCTIONS TO CANDIDATES

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- You are advised to show all the steps in any calculations.
- Where you see this icon you will be awarded marks for the quality of written communication in your answer.
  This means for example you should:
  - ensure that text is legible and that spelling, punctuation and grammar are accurate so that meaning is clear;
  - organise information clearly and coherently, using specialist vocabulary when appropriate.
- This document consists of **16** pages. Any blank pages are indicated.

Answer **all** the questions.

1 (a) State Newton's second and third laws of motion.

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

(i) second law

....

....

.... **[1]**

(ii) third law

....

....

.... **[1]**

(b) A golfer uses a golf club to hit a stationary golf ball off the ground. Fig. 1.1 shows how the force F on the golf ball varies with time t when the club is in contact with the ball.

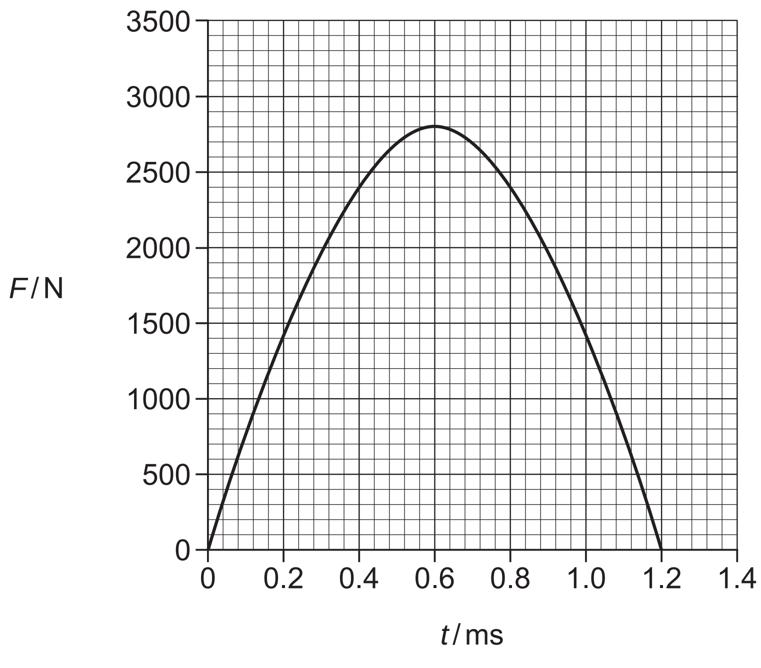

Fig. 1.1

(i) Estimate the area under the graph.

area = ... N s **[2]**

(ii) Name the physical quantity represented by the area under the graph in **(i)**.

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

.... **[1]**

(iii) Show that the speed of a golf ball, of mass 0.046 kg, as it leaves the golf club is about 50 $m\,s^{-1}$.

speed = ... $m\,s^{-1}$ **[2]**

(iv) The ground is level. The ball leaves the ground at a velocity of 50 $m\,s^{-1}$ at an angle of 42° to the horizontal. Determine the horizontal distance travelled by the ball before it hits the ground.

State **one** assumption that you make in your calculations.

distance = ... m

assumption ....

.... **[5]**

[Total: 12]

2 **(a)** Fig. 2.1 shows the London Eye.

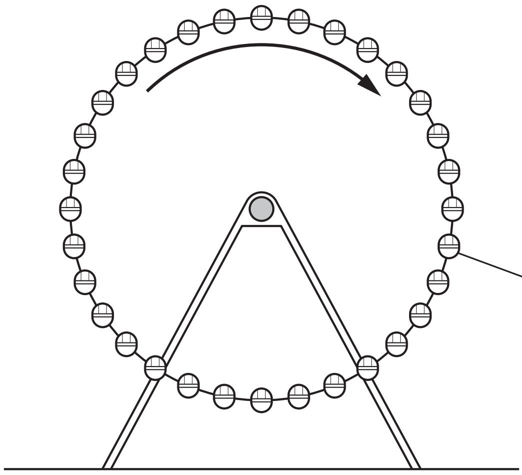

Fig. 2.1

It has 32 capsules equally spaced around the edge of a large vertical wheel of radius 60 m. The wheel rotates about a horizontal axis such that each capsule has a constant speed of 0.26 $m\,s^{-1}$.

(i) Calculate the time taken for the wheel to make one complete rotation.

time = ... s **[1]**

(ii) Each capsule has a mass of 9.7×10^3 kg. Calculate the centripetal force which must act on the capsule to make it rotate with the wheel.

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

(b) Fig. 2.2 shows the drum of a spin-dryer as it rotates. A dry sock **S** is shown on the inside surface of the side of the rotating drum.

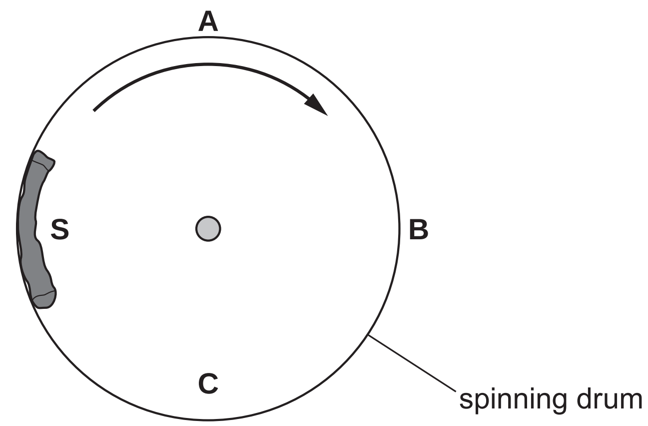

Fig. 2.2

(i) Draw arrows on Fig. 2.2 to show the direction of the centripetal force acting on **S** when it is at points **A**, **B** and **C**. **[1]**

(ii) State and explain at which position, **A**, **B** or **C** the normal contact force between the sock and the drum will be

1 the greatest

....

....

....

.... **[2]**

2 the least.

....

....

.... **[1]**

[Total: 7]

3 Fig. 3.1 represents the planet Jupiter. The centre of the planet is labelled as **O**.

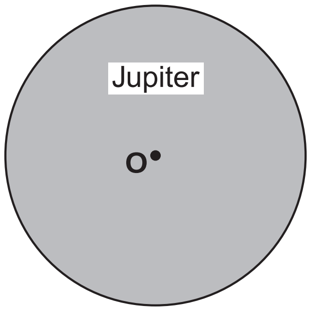

Fig. 3.1

(a) Draw gravitational field lines on Fig. 3.1 to represent Jupiter's gravitational field. **[2]**

(b) Jupiter has a radius of 7.14×10^{7} m and the gravitational field strength at its surface is $24.9\,\text{N}\,\text{kg}^{-1}$.

(i) Show that the mass of Jupiter is about 2×10^{27} kg.

[3]

(ii) Calculate the average density of Jupiter.

density = ... $\text{kg}\,\text{m}^{-3}$ **[2]**

[Total: 7]

4 Fig. 4.1 shows a mass suspended from a spring.

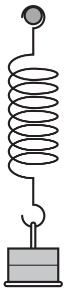

Fig. 4.1

(a) The mass is in equilibrium. By referring to the forces acting on the mass, explain what is meant by *equilibrium*.

....

....

.... **[2]**

(b) The mass in **(a)** is pulled down a vertical distance of 12 mm from its equilibrium position. It is then released and oscillates with simple harmonic motion.

(i) Explain what is meant by *simple harmonic motion*.

....

....

....

.... **[2]**

(ii) The displacement x, in mm, at a time t seconds after release is given by

$$x = 12\cos(7.85t).$$

Use this equation to show that the frequency of oscillation is 1.25 Hz.

[2]

(iii) Calculate the maximum speed V_{max} of the mass.

V_{max} = ... $m\,s^{-1}$ **[2]**

(c) Fig. 4.2 shows how the displacement *x* of the mass varies with time *t*.

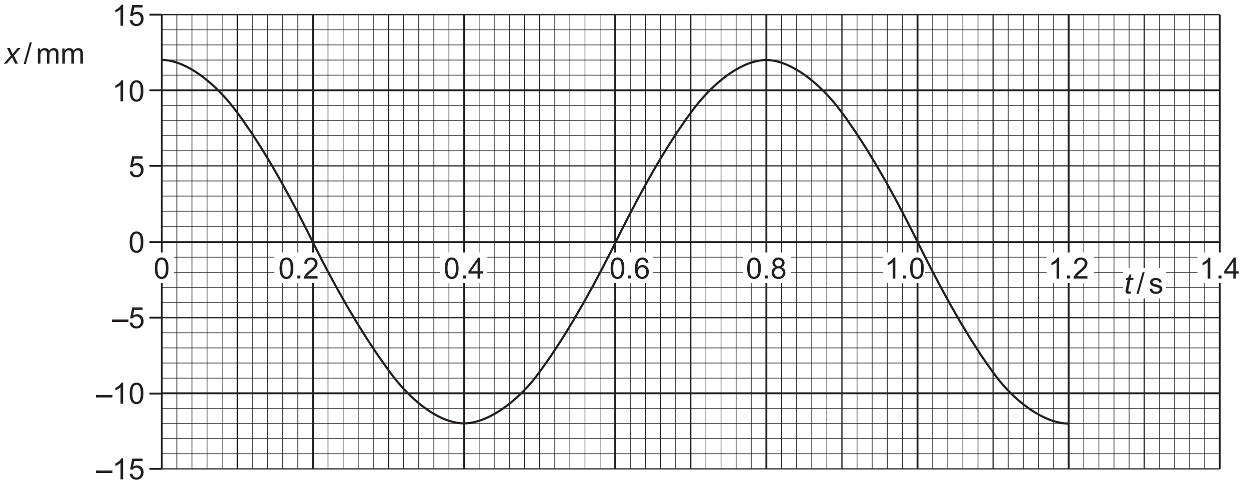

Fig. 4.2

Sketch on Fig. 4.3 the graph of velocity against time for the oscillating mass.

Put a suitable scale on the velocity axis. **[3]**

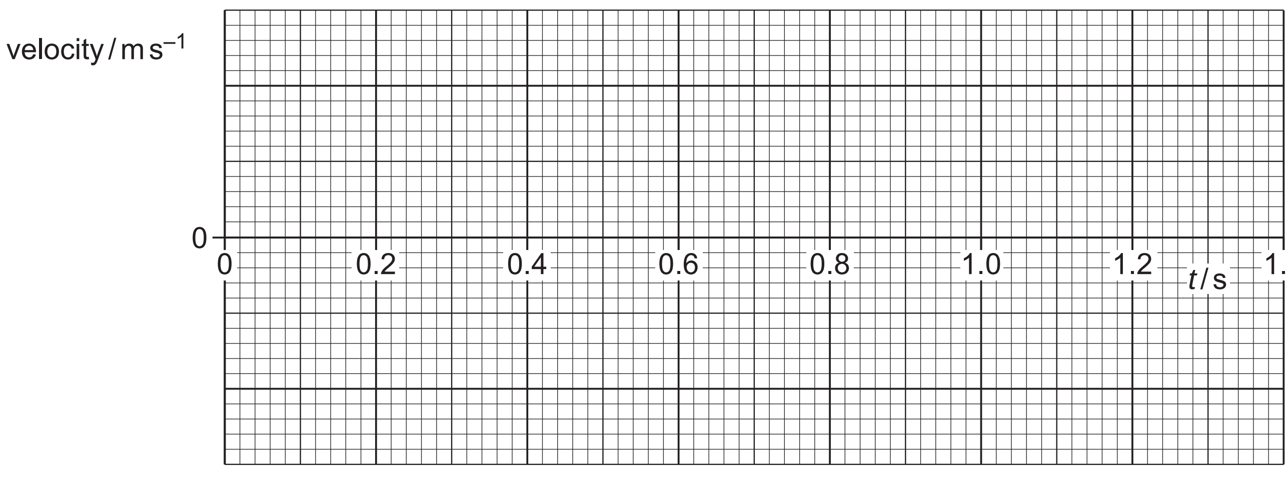

Fig. 4.3

[Total: 11]

5 **(a)** The table shows the specific heat capacities *c* of alcohol and water.

	c / J kg^{-1} K^{-1}
alcohol	2460
water	4180

(i) An alcohol thermometer is placed in 80 g of water at 20 °C. The mass of alcohol in the thermometer is 0.050 g. The water is then heated from 20 °C to 60 °C.

Calculate the ratio

$$\frac{\text{energy required to warm the water from 20 °C to 60 °C}}{\text{energy required to warm the alcohol from 20 °C to 60 °C}}.$$

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

(ii) State and explain a situation in which the very high value of specific heat capacity for water is useful.

....

....

....

....

.... **[2]**

(b) Describe an electrical experiment to determine the specific heat capacity *c* of a liquid.

Include in your answer:

- a labelled diagram of the arrangement
- a list of the measurements to be taken
- an explanation of how the value of *c* would be determined from your results
- possible sources of uncertainty in your measurements and how these could be reduced.

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.... **[8]**

[Total: 12]

6 **(a)** The ideal gas equation may be written as

$$pV = nRT.$$

State the meaning of the terms n and T.

n ....

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

(b) Fig. 6.1 shows a cylinder that contains a fixed amount of an ideal gas. The cylinder is fitted with a piston that moves freely. The gas is at a temperature of 20 °C and the initial volume is $1.2 \times 10^{-4}\,m^3$. Fig. 6.2 shows the cylinder after the gas has been heated to a temperature of 90 °C under constant pressure.

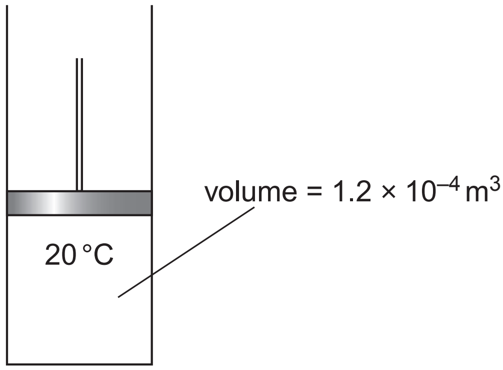

Fig. 6.1

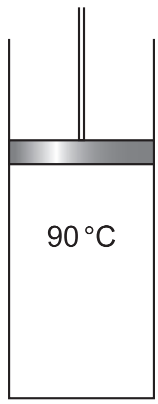

Fig. 6.2

(i) Explain in terms of the motion of the molecules of the gas why the volume of the gas must increase if the pressure is to remain constant as the gas is heated.

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.... **[4]**

(ii) Calculate the volume of the gas at 90 °C.

volume = ... m^3 **[2]**

(c) The mass of each gas molecule is 4.7×10^{-26} kg. Estimate the average speed of the gas molecules at 90 °C.

speed = ... $m\,s^{-1}$ **[3]**

[Total: 11]

END OF QUESTION PAPER

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PHYSICS A

G484

The Newtonian World

Candidates answer on the Question Paper

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Tuesday 29 June 2010
Afternoon

Duration: 1 hour

Candidate Forename		Candidate Surname	

Centre Number						Candidate Number				

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Answer **all** the questions.

1 **(a)** A particular collision between two objects is *inelastic*. Place a tick (✓) at the end of each statement that applies to such a collision. **[2]**

Statement	
The magnitude of the impulse on each object is the same.	
Kinetic energy and momentum for the objects are conserved.	
Total energy is conserved.	
After the collision, the objects have the same momentum.	

(b) Fig. 1.1 shows a tennis ball before and after striking a wall at right angles.

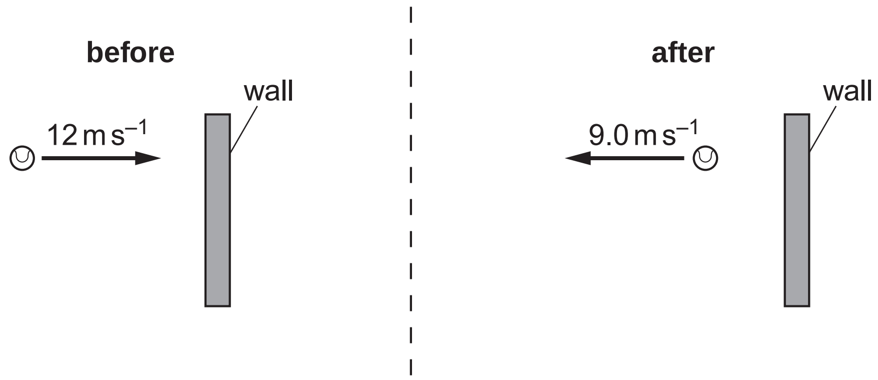

Fig. 1.1

The ball of mass 0.060 kg hits the wall at a speed of 12 m s^{-1}. The ball is in contact with the wall for 0.15 s. It rebounds with a speed of 9.0 m s^{-1}. Calculate

(i) the loss of kinetic energy during the collision

loss of kinetic energy = ... J **[2]**

(ii) the magnitude of the average force exerted on the ball by the wall

average force on ball = ... N **[2]**

(iii) the magnitude of the average force exerted on the wall by the ball during this collision.

average force on wall = ... N **[1]**

(c) (i) State **three** assumptions of the kinetic model of ideal gases.

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.... **[3]**

(ii) Use the kinetic theory of gases to explain how a gas exerts a pressure.

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.... **[3]**

[Total: 13]

2 **(a)** Fig. 2.1 shows an aeroplane flying in a horizontal circle at constant speed. The weight of the aeroplane is *W* and *L* is the lift force acting at right angles to the wings.

Fig. 2.1

(i) Explain how the lift force *L* maintains the aeroplane flying in a **horizontal** circle.

....

....

....

.... **[2]**

(ii) The aeroplane of mass 1.2×10^5 kg is flying in a horizontal circle of radius 2.0 km.

The centripetal force acting on the aeroplane is 1.8×10^6 N. Calculate the speed of the aeroplane.

speed = ... $m\,s^{-1}$ **[2]**

(b) Fig. 2.2 shows a satellite orbiting the Earth at a constant speed *v*. The radius of the orbit is *r*.

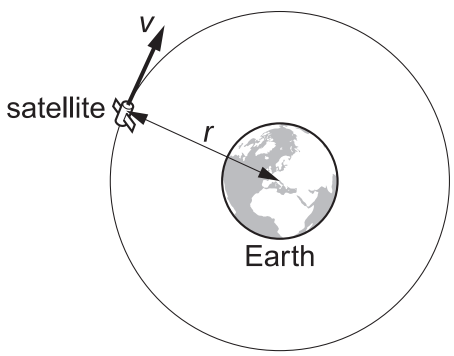

Fig. 2.2

Show that the orbital period T of the satellite is given by the equation

$$T^2 = \frac{4\pi^2 r^3}{GM}$$

where M is the mass of the Earth and G is the gravitational constant.

[3]

(c) The satellites used in television communication systems are usually placed in geostationary orbits.

In your answer, you should use appropriate technical words spelled correctly.

(i) State two features of geostationary orbits.

1. ....

....

2. ....

.... **[2]**

(ii) Calculate the radius of orbit of a geostationary satellite.

The mass of the Earth is 6.0×10^{24} kg.

radius = ... m **[3]**

[Total: 12]

3 **(a)** State two conditions concerning the **acceleration** of an oscillating object that must apply for simple harmonic motion.

1. ....

....

2. ....

....

.... **[2]**

(b) Fig. 3.1 shows how the potential energy, in mJ, of a simple harmonic oscillator varies with displacement.

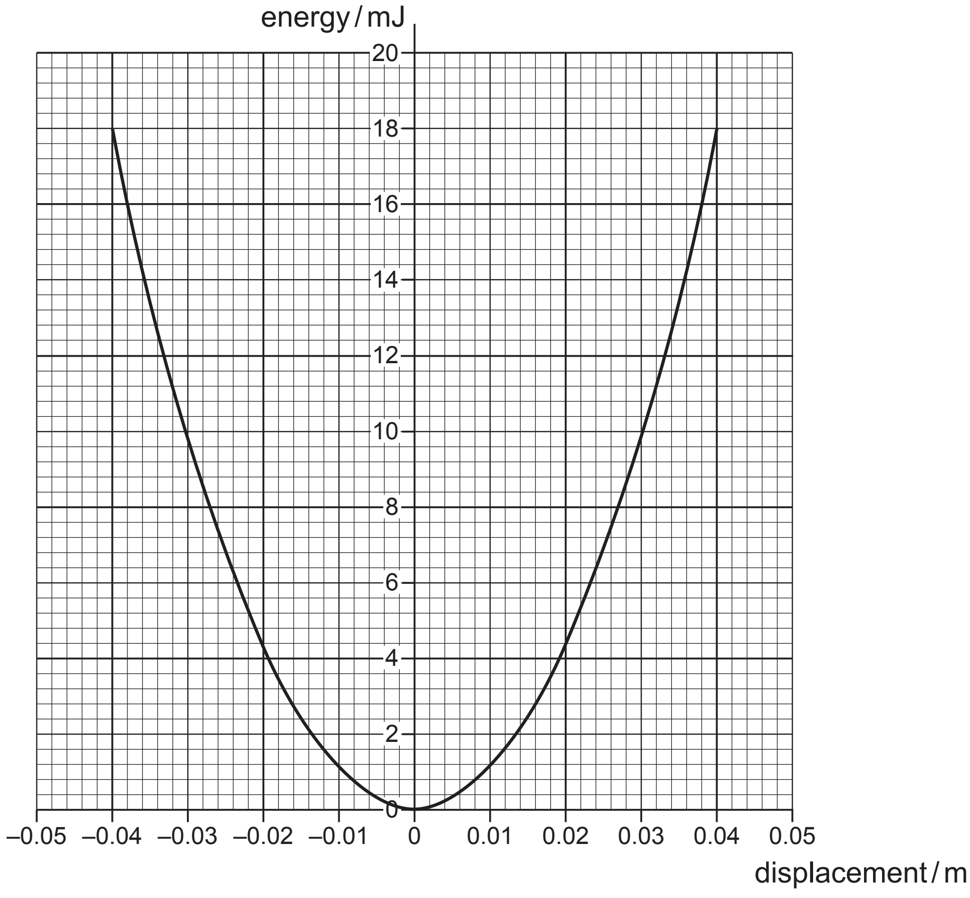

Fig. 3.1

On Fig. 3.1 sketch graphs to show the variation of

(i) kinetic energy of the oscillator with displacement – label this graph **K** **[2]**

(ii) the total energy of the oscillator with displacement – label this graph **T**. **[1]**

(c) Use Fig. 3.1 to determine

(i) the amplitude of the oscillations

amplitude = ... m **[1]**

(ii) the maximum speed of the oscillator of mass 0.12 kg

maximum speed = ... $m\,s^{-1}$ **[2]**

(iii) the frequency of the oscillations.

frequency = ... Hz **[2]**

(d) Resonance can either be useful or a problem. Describe one example where resonance has a useful application and one example where resonance is a problem or nuisance. For each example identify what is oscillating and what causes these oscillations.

(i) useful application

....

....

....

....

.... **[2]**

(ii) problem

....

....

....

....

.... **[2]**

[Total: 14]

4 Fig. 4.1 shows smoke particles suspended in air. The arrows indicate the directions in which the smoke particles are moving at a particular instant. The lengths of the arrows indicate the different speeds of the particles.

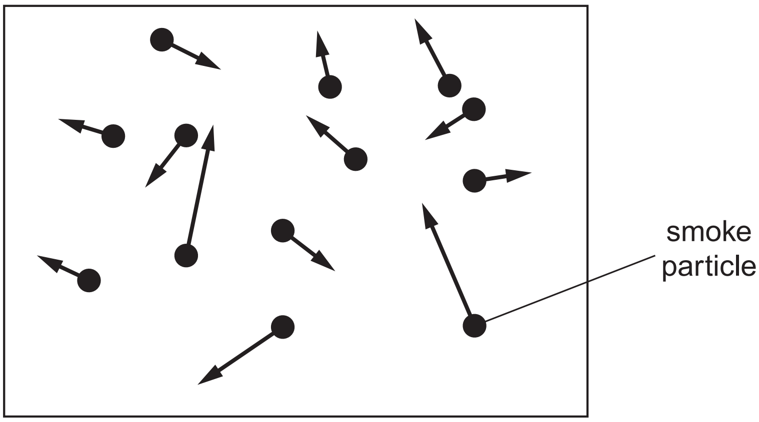

Fig. 4.1

(a) (i) State the name given to this type of random motion of smoke particles in air.

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

....

.... **[1]**

(ii) State **two** conclusions about the air molecules that may be deduced from the observed motion of the smoke particles.

....

....

....

.... **[2]**

(b) (i) The radius of an inflated football is 0.11 m. The temperature of the air inside the ball is 17 °C. Calculate the mass of air in the ball when the pressure inside it is 2.6×10^5 Pa.

The mass of one mole of air is 0.028 kg.

mass of air = ... kg **[4]**

(ii) The football is left in a room at a temperature of 0 °C until it reaches thermal equilibrium.

1 Explain the term *thermal equilibrium*.

....

....

.... **[1]**

2 Calculate the pressure exerted by the air inside the football when the temperature drops to 0 °C.

pressure = ... Pa **[2]**

[Total: 10]

5 A car of mass 970 kg is travelling at 27 m s^{-1} when the brakes are applied. The car is brought to rest in a distance of 40 m.

(a) (i) Calculate the kinetic energy of the car when it is travelling at 27 m s^{-1}.

kinetic energy = ... J **[1]**

(ii) Hence calculate the average braking force on the car stating any assumption that you make.

average braking force = ... N

assumption ....

.... **[3]**

(b) The car has four brake discs each of mass 1.2 kg. The material from which the discs are made has a specific heat capacity of 520 J kg^{-1} K^{-1}.

(i) Calculate the temperature rise of each disc after braking from a speed of 27 m s^{-1}. Assume all the kinetic energy of the car is converted into internal energy of the brake discs equally during braking.

temperature rise = ... °C **[2]**

(ii) State and explain **two** reasons why the actual temperature rise will be different.

....

....

....

....

....

....

....

.... **[4]**

(iii) Suggest one modification to the design of the disc braking system that could reduce the temperature rise of the discs.

....

....

.... **[1]**

[Total: 11]

END OF QUESTION PAPER

OCR
RECOGNISING ACHIEVEMENT

ADVANCED GCE

PHYSICS A

G484

The Newtonian World

Thursday 27 January 2011
Afternoon

Duration: 1 hour

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Answer **all** the questions.

1 (a) (i) State the principle of *conservation of linear momentum*.

....

....

.... **[2]**

(ii) Explain what is meant by an *inelastic collision*.

....

.... **[1]**

(iii) Fig. 1.1 shows the head-on-collision of two blocks on a frictionless surface.

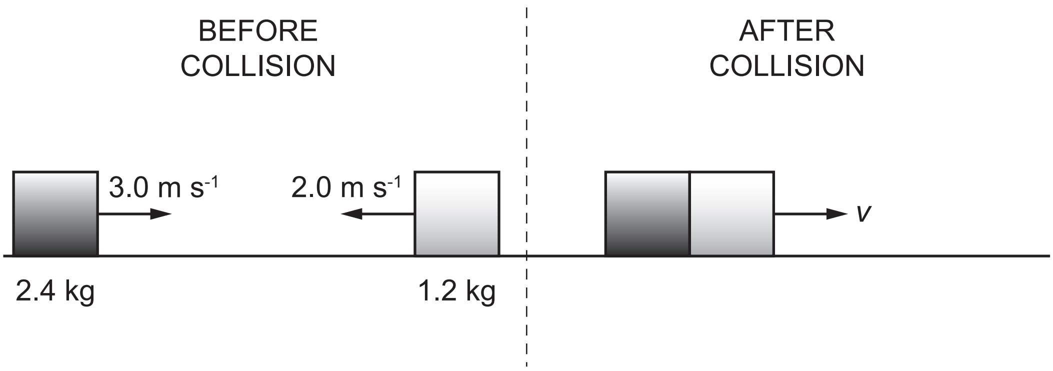

Fig. 1.1

Before the collision, the 2.4 kg block is moving to the right with a speed of 3.0 m s^{-1} and the 1.2 kg block is moving to the left at a speed of 2.0 m s^{-1}. During the collision the blocks stick together. Immediately after the collision the blocks have a common speed v.

1 Calculate the speed v.

v = ... m s^{-1} **[2]**

2 Show that this collision is inelastic.

[2]

(b) Fig. 1.2 shows a helicopter viewed from above.

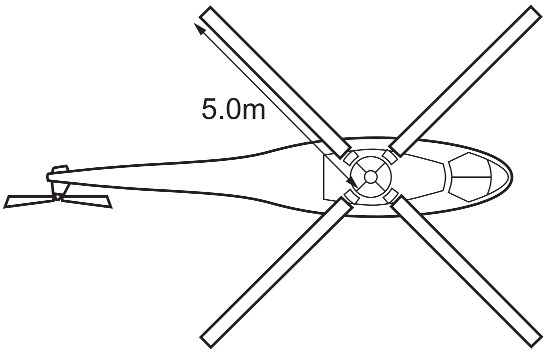

Fig. 1.2

The blades of the helicopter rotate in a circle of radius 5.0 m. When the helicopter is hovering, the blades propel air vertically downwards with a constant speed of $12\,m\,s^{-1}$. Assume that the descending air occupies a uniform cylinder of radius 5.0 m.

The density of air is $1.3\,kg\,m^{-3}$.

(i) Show that the mass of air propelled downwards in a time of 5.0 seconds is about 6000 kg.

[2]

(ii) Calculate

1 the momentum of this mass of descending air

momentum = ... kg m s^{-1} **[1]**

2 the force provided by the rotating helicopter blades to propel this air downwards

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

3 the mass of the hovering helicopter.

mass = ... kg **[1]**

[Total: 13]

2 **(a)** **(i)** State, in terms of force, the conditions necessary for an object to move in a circular path at constant speed.

....

.... **[1]**

(ii) Explain why this object is accelerating. State the direction of the acceleration.

....

.... **[2]**

(b) A satellite moves in a circular orbit around the Earth at a constant speed of 3700 $m\,s^{-1}$.

The mass M of the Earth is 6.0×10^{24} kg.

Calculate the radius of this orbit.

radius = ... m **[4]**

(c) In order to move the satellite in **(b)** into a new smaller orbit, a decelerating force is applied for a brief period of time.

(i) Suggest how the decelerating force could be applied.

....

.... **[1]**

(ii) The radius of this new orbit is 2.0×10^{7} m. Calculate the speed of the satellite in this orbit.

speed = ... $m\,s^{-1}$ **[2]**

[Total: 10]

3 **(a)** **(i)** Define the *kilowatt-hour*.

....

.... **[1]**

(ii) A domestic refrigerator works at a mean power of 70 W. Calculate the cost of running this refrigerator for one week at a cost of 12 p per kW h.

cost = £ .... **[2]**

(b) A large jug containing 2.0 kg of milk is placed in a refrigerator. The milk cools from 18 °C to 3.0 °C over a time period of 100 minutes. The specific heat capacity of milk is 3800 $J\,kg^{-1}\,K^{-1}$.

Calculate

(i) the thermal energy removed from the milk as it cools from 18 °C to 3 °C

energy removed = ... J **[2]**

(ii) the rate at which thermal energy is removed from the milk.

rate = ... $J\,s^{-1}$ **[1]**

(c) Another container full of milk is placed in a freezer and cooled from 18 °C to –18 °C.

Assume that thermal energy is removed at a constant rate and that the freezing-point of milk is 0 °C. The specific heat capacity of milk below 0 °C is significantly less than its value above 0 °C.

On Fig. 3.1 sketch a graph to show the variation with time of the temperature of the milk over the range 18 °C to –18 °C. Numbers are not required on the time axis.

Fig. 3.1 **[3]**

[Total: 9]

4 (a) For a body undergoing simple harmonic motion describe the difference between

(i) *displacement* and *amplitude*

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

....

....

.... **[2]**

(ii) *frequency* and *angular frequency*.

....

....

.... **[2]**

(b) A harbour, represented in Fig. 4.1, has vertical sides and a flat bottom. The surface of the water in the harbour is calm.

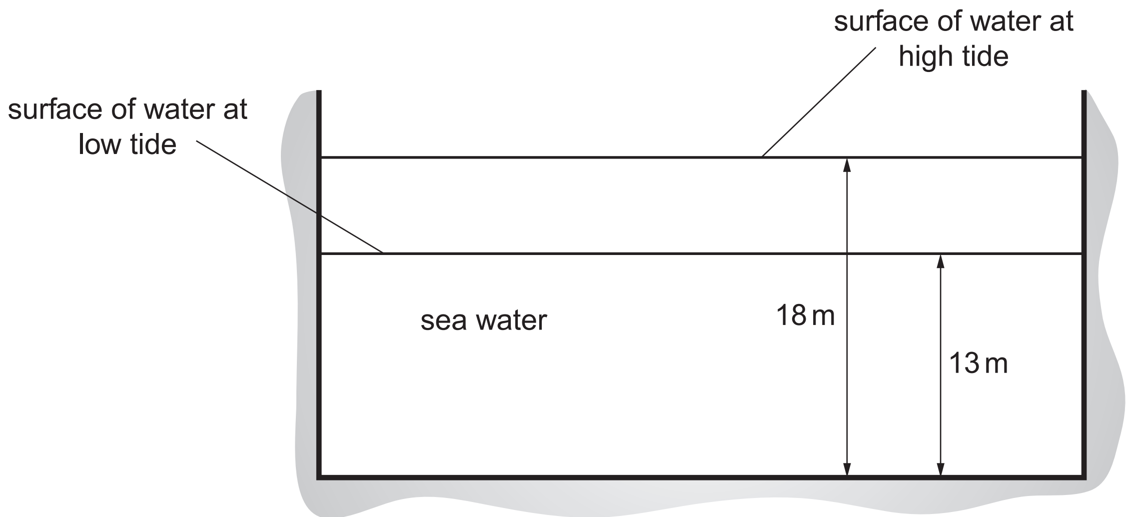

Fig. 4.1

The tide causes the surface of the water to perform simple harmonic motion with a period of 12.5 hours. The maximum depth of the water is 18 m and the minimum depth is 13 m.

(i) For the oscillation of the water surface, calculate

1 the amplitude

amplitude = ... m **[1]**

2 the frequency.

frequency = ... Hz **[2]**

(ii) Calculate the maximum vertical speed of the water surface.

maximum speed = ... $m\,s^{-1}$ **[2]**

(iii) Write an expression for the depth *d* in metres of water in the harbour in terms of time *t* in seconds.

[2]

[Total: 11]

5 (a) A student investigates Brownian motion by observing through a microscope smoke particles suspended in air.

(i) Describe the behaviour of the smoke particles as observed by the student.

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

....

.... **[1]**

(ii) State how the observations lead to conclusions about the nature and properties of the molecules of a gas.

....

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....

....

.... **[3]**

(b) The molar masses of hydrogen and oxygen are 0.0020 kg mol^{-1} and 0.032 kg mol^{-1} respectively. The mean speed of hydrogen molecules at room temperature is 1800 m s^{-1}.

Calculate the mean speed of oxygen molecules at the same temperature.

mean speed = ... m s^{-1} **[3]**

[Total: 7]

6 **(a)** **(i)** State Boyle's law.

....

.... **[2]**

(ii) For a gas which obeys Boyle's law, sketch

1 on Fig. 6.1 a graph of pressure *p* against volume *V*

2 on Fig. 6.2 a graph of *p* against 1 / *V*. **[3]**

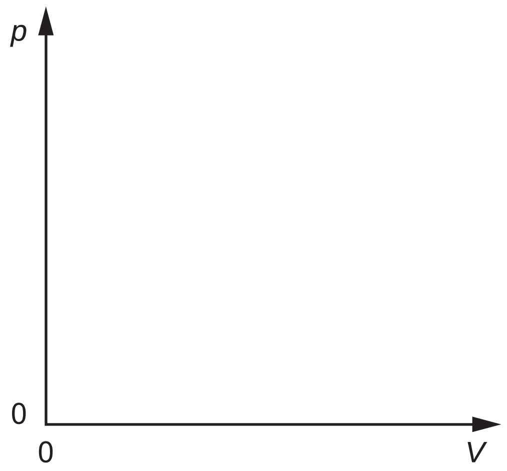

Fig. 6.1

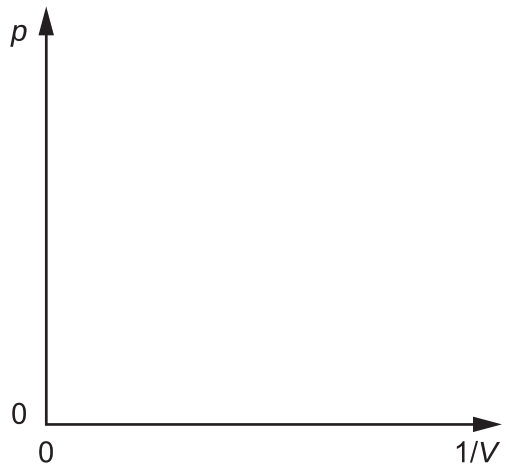

Fig. 6.2

Question 6 continues over the page.

(b) A cylinder of fixed volume 0.040 m^3 is filled with nitrogen gas at a pressure of 5.0×10^5 Pa and temperature 15 °C. The molar mass of nitrogen is 0.028 kg mol^{-1}.

(i) Calculate the number of moles of nitrogen in the cylinder.

number of moles = ... **[2]**

(ii) After a period of 100 days the pressure has fallen to 4.5×10^5 Pa, at the same temperature, because of leakage. Calculate the mass of nitrogen that has escaped.

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

[Total: 10]

END OF QUESTION PAPER

OCR
RECOGNISING ACHIEVEMENT

ADVANCED GCE

PHYSICS A

The Newtonian World

G484

Candidates answer on the question paper.

OCR supplied materials:
- Data, Formulae and Relationships Booklet

Other materials required:
- Electronic calculator

Monday 27 June 2011
Morning

Duration: 1 hour

Candidate forename		Candidate surname	

Centre number						Candidate number				

INSTRUCTIONS TO CANDIDATES

- Write your name, centre number and candidate number in the boxes above. Please write clearly and in capital letters.
- Use black ink. Pencil may be used for graphs and diagrams only.
- Read each question carefully. Make sure you know what you have to do before starting your answer.
- Write your answer to each question in the space provided. If additional space is required, you should use the lined pages at the end of this booklet. The question number(s) must be clearly shown.
- Answer **all** the questions.
- Do **not** write in the bar codes.

INFORMATION FOR CANDIDATES

- The number of marks is given in brackets **[ ]** at the end of each question or part question.
- The total number of marks for this paper is **60**.
- You may use an electronic calculator.
- You are advised to show all the steps in any calculations.
- Where you see this icon you will be awarded marks for the quality of written communication in your answer.
  This means for example you should:
  - ensure that text is legible and that spelling, punctuation and grammar are accurate so that meaning is clear;
  - organise information clearly and coherently, using specialist vocabulary when appropriate.
- This document consists of **12** pages. Any blank pages are indicated.

Answer **all** the questions.

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

....

....

.... **[1]**

(ii) Define the *newton*.

....

.... **[1]**

(b) A jet plane on the deck of an aircraft carrier is accelerated before take-off using a catapult. The mass of the plane is 3.2×10^4 kg and it is accelerated from rest to a velocity of $55\,\text{m}\,\text{s}^{-1}$ in a time of 2.2 s. Calculate

(i) the mean acceleration of the plane

mean acceleration = ... $\text{m}\,\text{s}^{-2}$ **[2]**

(ii) the distance over which the acceleration takes place

distance = ... m **[2]**

(iii) the mean force producing the acceleration.

mean force = ...N **[1]**

(c) The jet plane describes a **horizontal** circle of radius 870 m flying at a constant speed of 120 m s^{-1}.

(i) State the direction of the resultant horizontal force acting on the plane.

.... **[1]**

(ii) Calculate the magnitude of this horizontal force.

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

(d) By changing the velocity of the plane it can be made to fly in a **vertical** circle of radius 1500 m. At a particular point in the vertical circle, the contact force between the pilot and his seat may be zero and the pilot experiences "weightlessness".

(i) State and explain at what point in the circle this weightlessness may occur.

....

....

....

.... **[2]**

(ii) Calculate the speed of the plane at which weightlessness occurs.

speed = ... m s^{-1} **[2]**

[Total: 14]

2 **(a)** Fig. 2.1 shows a mass attached to the end of a spring. The mass is pulled down and then released. The mass performs vertical simple harmonic motion.

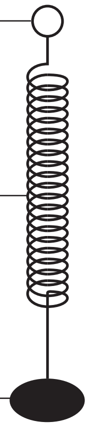

Fig. 2.1

(i) Define *simple harmonic motion*.

....

....

....

.... **[2]**

(ii) Mark the following statements about the oscillating mass-spring system as *true* or *false*. **[2]**

statement	**true/false**
The period of oscillation is constant.	
The net force on the mass is equal to its weight.	
The acceleration of the mass is a maximum at the mid-point of the oscillations.	
The velocity of the mass is proportional to the displacement.	

(b) A student wishes to investigate whether the period of oscillation of a simple pendulum is constant for all angles of swing. Describe how the student should carry out the investigation. Include the following in your description:

- a sketch of the apparatus with angle of swing labelled
- details of how the measurements would be made
- how these results would be used to form a conclusion
- the major difficulty likely to be encountered and how this might be overcome.

Sketch:

....

....

....

....

....

....

....

....

....

....

....

....

....

....

.... **[5]**

[Total: 9]

3 **(a)** Define *gravitational field strength*.

....

.... **[1]**

(b) The table shows, in modern units, information that was known to physicists at the time of Isaac Newton.

position	distance *r* from centre of the Earth / km	gravitational field strength *g* due to the Earth / N kg^{-1}
surface of Earth	6.4×10^3	9.8
Moon's orbit	3.8×10^5	2.7×10^{-3}

Use the information provided in the table to

(i) state a relationship between the gravitational field strength *g* and the distance *r* and verify this relationship

....

.... **[3]**

(ii) show that the mass of the Earth is about 6×10^{24} kg

[2]

(iii) determine the mean density of the Earth.

density = ... kg m^{-3} **[2]**

[Total: 8]

4 (a) *In your answer you should use appropriate technical terms spelled correctly.*

State the terms used to describe the thermal energy required to change

(i) a solid into a liquid at a constant temperature

.... **[1]**

(ii) a liquid into a gas at a constant temperature.

.... **[1]**

(b) Most households waste energy by overfilling electric kettles. Assume that, on average, 0.80 kg of water per household per day is unnecessarily boiled.

(i) Estimate the energy required when 0.80 kg of water, initially at 18 °C, is heated in an electric kettle. The kettle switches off automatically when the water is boiling steadily at 100 °C. The specific heat capacity of water is 4200 $J\,kg^{-1}\,K^{-1}$.

heat energy = ... J **[2]**

(ii) State and explain **two** different reasons why the actual quantity of energy required to warm the water to 100 °C is greater than the estimate in **(i)**.

1. ....

....

2. ....

.... **[2]**

(iii) Calculate, in kW h, the average annual energy wasted per household by boiling too much water.

energy = ...kW h **[2]**

[Total: 8]

5 **(a)** One assumption required for the development of the kinetic model of a gas is that molecules undergo perfectly elastic collisions with the walls of their containing vessel and with each other.

(i) Explain what is meant by a *perfectly elastic collision*.

....

.... **[1]**

(ii) State **three** other assumptions of the kinetic theory of gases.

1. ....

....

2. ....

....

3. ....

.... **[3]**

(b) Fig. 5.1 shows a cubical box of side length 0.20 m. The box contains one molecule of mass 4.8×10^{-26} kg moving with a constant speed of 500 m s^{-1}. The molecule collides elastically at right angles with the opposite faces **X** and **Y** of the box.

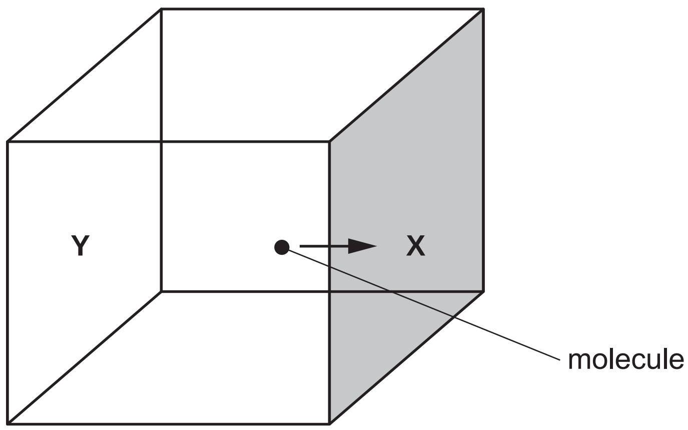

Fig. 5.1

(i) Calculate the change of momentum each time the molecule collides with face **X**.

change of momentum = ... kg m s^{-1} **[2]**

(ii) Calculate the number of collisions made by the molecule with face **X** in 1.0 s.

number = ... **[1]**

(iii) Calculate the mean force exerted on the molecule by face **X**.

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

(iv) Hence state the force exerted on face **X** by the molecule. Justify your answer.

....

.... **[1]**

(c) The single molecule in the box in **(b)** is replaced by 3 moles of air at atmospheric pressure.

(i) Calculate the number of air molecules in the box.

number = ... **[1]**

(ii) Suggest why the pressure exerted by the air on each of the six faces of the box is the same.

....

.... **[1]**

(iii) The temperature of the air inside the box is increased. Explain in terms of the **motion** of the air molecules how the pressure exerted by the air will change.

....

....

.... **[2]**

[Total: 14]

6 (a) (i) A container has **1 mole** of an ideal gas. The volume of the container is V cubic metres (m^3) and the gas exerts pressure p pascal (Pa). On Fig. 6.1, show the relationship between the product pV and the absolute temperature T of the gas. **[1]**

Fig. 6.1

(ii) State the value of the gradient of this graph.

.... **[1]**

(b) The volume of 1.5 moles of an ideal gas at −40 °C is $2.4 \times 10^{-2}\,m^3$. The gas is now heated at constant pressure p. Calculate

(i) the new volume of the gas at a temperature of 250 °C

volume = ... m^3 **[3]**

(ii) the value of the pressure p.

p = ... Pa **[2]**

[Total: 7]

END OF QUESTION PAPER

OCR
RECOGNISING ACHIEVEMENT

Tuesday 24 January 2012 – Afternoon

A2 GCE PHYSICS A

G484 The Newtonian World

Candidates answer on the Question Paper.

OCR supplied materials:
- Data, Formulae and Relationships Booklet (sent with general stationery)

Other materials required:
- Electronic calculator

Duration: 1 hour 15 minutes

Candidate forename		Candidate surname	

Centre number						Candidate number				

INSTRUCTIONS TO CANDIDATES

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- Use black ink. HB pencil may be used for graphs and diagrams only.
- Answer **all** the questions.
- Read each question carefully. Make sure you know what you have to do before starting your answer.
- Write your answer to each question in the space provided. Additional paper may be used if necessary but you must clearly show your candidate number, centre number and question number(s).
- Do **not** write in the bar codes.

INFORMATION FOR CANDIDATES

- The number of marks is given in brackets **[ ]** at the end of each question or part question.
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- You are advised to show all the steps in any calculations.
-  Where you see this icon you will be awarded marks for the quality of written communication in your answer.
  This means for example you should:
  - ensure that text is legible and that spelling, punctuation and grammar are accurate so that meaning is clear;
  - organise information clearly and coherently, using specialist vocabulary when appropriate.
- This document consists of **12** pages. Any blank pages are indicated.

Answer **all** the questions.

1 (a) (i) Define *linear momentum*.

....

.... **[1]**

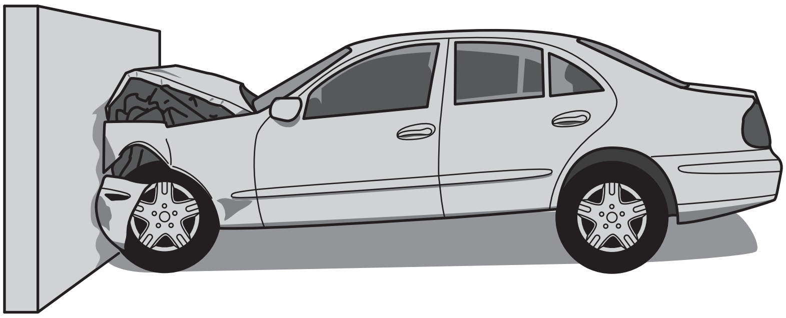
(ii) Linear momentum is a vector quantity. Explain why.

....

....

.... **[2]**

(b) The crumple zone of a car is a hollow structure at the front of the car designed to collapse during a collision. In a laboratory road-test, a car of mass 850 kg was driven into a concrete wall. A video recording of the impact showed that the car, initially travelling at 7.5 m s^{-1}, was brought to rest in 0.28 s when it hit the wall.



(i) Calculate

1 the deceleration of the car, assuming it to be uniform

deceleration = ... m s^{-2} **[1]**

2 the average force exerted by the wall on the car.

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

(ii) The crumple zone of the car is designed to absorb 0.45 MJ of energy before any distortion of the passenger cabin occurs. For this design of crumple zone, calculate the maximum speed of the car at impact.

speed = ... $m\,s^{-1}$ **[2]**

(c) In a different test, another car of mass 850 kg is travelling at a speed of 7.5 $m\,s^{-1}$. It makes a head-on collision with a stationary car of mass 1200 kg. Immediately after the impact, both cars move off together with a common speed *v*. Calculate this speed.

v = ... $m\,s^{-1}$ **[2]**

[Total: 10]

2 Fig. 2.1 shows a displacement against time graph for an oscillating mass.

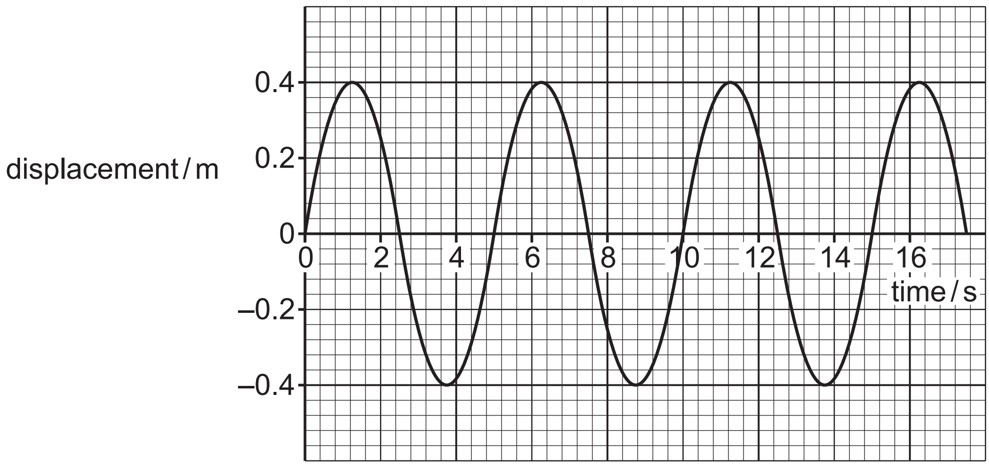


Fig. 2.1

(a) Use Fig. 2.1 to determine, for the oscillations of the mass,

(i) the amplitude and period

amplitude = ... m

period = ... s **[1]**

(ii) the angular frequency, ω.

ω = ... rad s^{-1} **[2]**

(b) Mark with a cross (**X**) on Fig. 2.1, using a different position in each case,

(i) a point where the velocity of the mass is a maximum; label it **V** **[1]**

(ii) a point where the acceleration of the mass is zero; label it **A** **[1]**

(iii) a point where the potential energy of the mass is a minimum; label it **P**. **[1]**

(c) The cone of a loudspeaker oscillates with simple harmonic motion. It vibrates with a frequency of 2.4 kHz and has an amplitude of 1.8 mm.

(i) Calculate the maximum acceleration of the cone.

acceleration = ... $m\,s^{-2}$ **[3]**

(ii) The cone experiences a mean damping force of 0.25 N. Calculate the average power needed to be supplied to the cone to keep it oscillating with a constant amplitude.

power = ... W **[3]**

[Total: 12]

3 (a) (i) State the name given to satellites that orbit the Earth, with a period of 1 day, above the equator.

You should use the appropriate technical term spelled correctly.

.... **[1]**

(ii) Explain why these satellites orbit above the equator.

....

.... **[1]**

(iii) For companies who provide a satellite TV service, suggest the main advantage of using this type of satellite.

....

.... **[1]**

(iv) The mass of the Earth is 6.0×10^{24} kg. Show that the radius of the orbit of a satellite with an orbital period of 1 day is about 4×10^{7} m.

[3]

(b) (i) State Kepler's third law.

....

.... **[1]**

(ii) The Moon orbits the Earth with a period of 27.3 days. Use the information given in **(a)(iv)** to calculate the following ratio:

$$\frac{\text{distance of the Moon from the Earth's centre}}{\text{distance of the satellite from the Earth's centre}}$$

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

[Total: 9]

4 **(a)** State the term used for the energy required to change a solid into a liquid.

You should use the appropriate technical term spelled correctly.

.... **[1]**

(b) **(i)** Define the *internal energy* of a system.

....

....

.... **[2]**

(ii) There is a change in internal energy when a mass of water at 100 °C becomes an equal mass of vapour at 100 °C. Explain why.

....

....

.... **[2]**

(c) **(i)** The air in a greenhouse has a volume of $15\,m^3$, a density of $1.2\,kg\,m^{-3}$ and a specific heat capacity of $990\,J\,kg^{-1}\,K^{-1}$. Immediately after sunset, the soil is transferring thermal energy to the air at an average rate of 12 W. Estimate the increase in temperature of the air in the greenhouse one hour after sunset as a result of this energy transfer from the soil.

increase in temperature = ... K **[3]**

(ii) Suggest two possible reasons why the actual increase in temperature of the air is likely to be much lower than this estimate.

....

....

.... **[2]**

[Total: 10]

5 (a) (i) State what is meant by a *perfectly elastic collision*.

....

.... **[1]**

(ii) Explain, in terms of the behaviour of **molecules**, how a gas exerts a pressure on the walls of its container.

....

....

....

....

....

....

.... **[4]**

(iii) Explain, in terms of the behaviour of **molecules**, why the pressure of a gas in a container of constant volume increases when the temperature of the gas is increased.

....

....

....

....

.... **[2]**

(b) A weather balloon is filled with helium gas. Just before take-off the pressure inside the balloon is 105 kPa and its internal volume is $5.0 \times 10^3\,m^3$. The temperature inside the balloon is 20 °C. The pressure, volume and temperature of the helium gas change as the balloon rises into the upper atmosphere.

(i) The balloon expands to a volume of $1.2 \times 10^4\,m^3$ in the upper atmosphere where the temperature inside the balloon is –30° C. Calculate the pressure inside the balloon.

pressure = ... kPa **[3]**

(ii) Suggest why it is necessary to release helium from the balloon as it continues to rise.

....

....

.... **[1]**

[Total: 11]

Question 6 is on page 10.

6 **(a)** The molar mass of hydrogen gas is $2.02 \times 10^{-3}\,\text{kg mol}^{-1}$. Calculate the mass of a hydrogen molecule.

mass = ... kg **[2]**

(b) The temperature of the Earth's upper atmosphere is about 1100 K. Show that at this temperature the mean kinetic energy of an air molecule is about 2×10^{-20} J.

[2]

(c) Show that the speed of a helium atom of mass 6.6×10^{-27} kg at a temperature of 1100 K is about $2.5\,\text{km s}^{-1}$.

[2]

(d) The *escape velocity* from the Earth is $11\,\text{km s}^{-1}$. The escape velocity is the minimum vertical velocity a particle must have in order to escape from the Earth's gravitational field. Explain why helium atoms still escape from the Earth's atmosphere.

....

....

....

....

.... **[2]**

[Total: 8]

END OF QUESTION PAPER

OCR
RECOGNISING ACHIEVEMENT

Monday 18 June 2012 – Morning

A2 GCE PHYSICS A

G484 The Newtonian World

Candidates answer on the Question Paper.

OCR supplied materials:
- Data, Formulae and Relationships Booklet (sent with general stationery)

Other materials required:
- Electronic calculator

Duration: 1 hour 15 minutes

Candidate forename		Candidate surname	

Centre number						Candidate number				

INSTRUCTIONS TO CANDIDATES

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- Answer **all** the questions.
- Read each question carefully. Make sure you know what you have to do before starting your answer.
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- Where you see this icon you will be awarded marks for the quality of written communication in your answer.
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  - organise information clearly and coherently, using specialist vocabulary when appropriate.
- This document consists of **16** pages. Any blank pages are indicated.

Answer **all** the questions.

1 **(a)** State the effect a net force has on the motion of an object.

....

....

.... **[1]**

(b) **(i)** Define the *impulse of a force*.

....

.... **[1]**

(ii) A force *F* is applied to an object. The graph in Fig. 1.1 shows the variation of this force with time *t*.

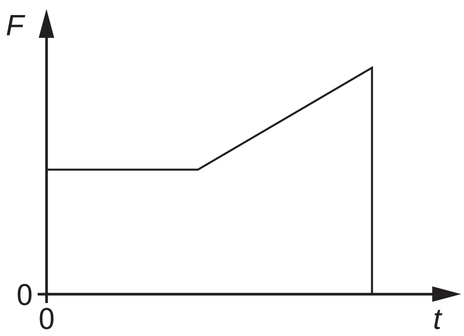


Fig. 1.1

The initial velocity of the object is zero and its mass is known. Explain how this graph can be used to determine the final velocity of the object.

....

....

....

.... **[2]**

(c) A tennis ball is hit by a racket as shown in Fig. 1.2.

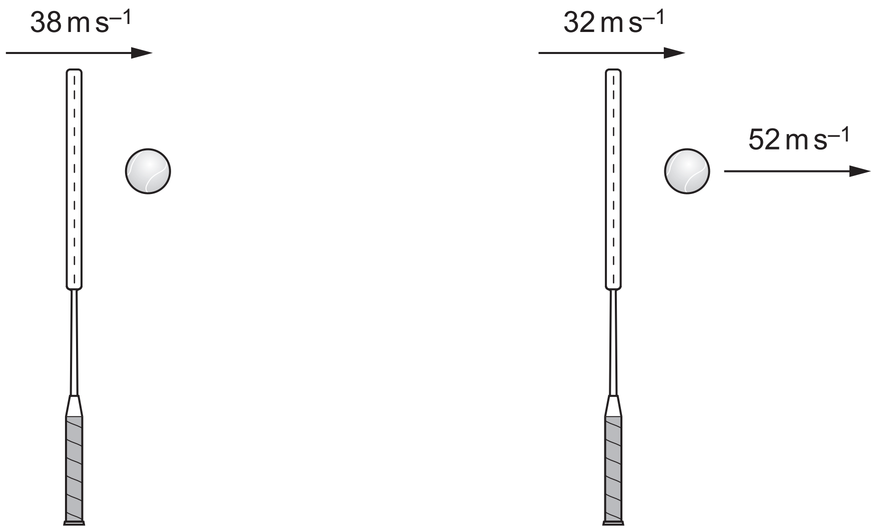


Fig. 1.2a **Fig. 1.2b**

Fig. 1.2

The mass of a tennis ball is 0.058 kg. During a serve the racket head and the ball are in contact for 4.2 ms. Just before contact, the racket head is travelling towards the ball at 38 m s^{-1} and the ball is stationary. Fig.1.2a shows the situation just before contact. Immediately after contact, the racket head is travelling in the same direction at 32 m s^{-1} and the ball is travelling away from the racket at 52 m s^{-1}. This is shown in Fig. 1.2b.

(i) Calculate the mean force provided by the racket on the ball.

mean force = ……………….N **[2]**

(ii) Estimate the mass of the racket.

mass = ……………….. kg **[2]**

(iii) Suggest why the value of the mass calculated in **(ii)** will be different from the actual mass of the racket.

....

.... **[1]**

[Total: 9]

2 **(a)** A body moves with simple harmonic motion. Define, in words, *simple harmonic motion*.

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

....

....

.... **[2]**

(b) A horizontal metal plate connected to a vibration generator is oscillating vertically with simple harmonic motion of period 0.080 s and amplitude 1.2 mm. There are dry grains of sand on the plate. Fig. 2.1 shows the arrangement.

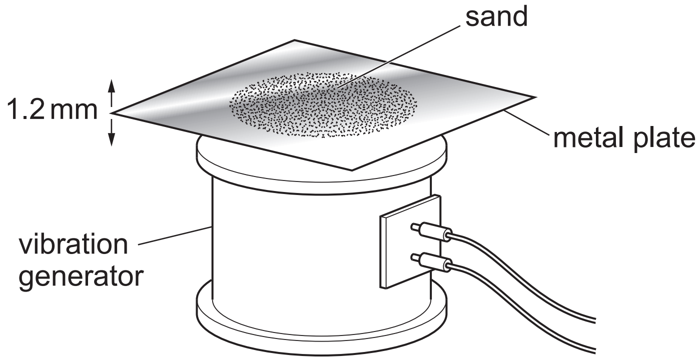


Fig. 2.1

(i) Calculate the maximum speed of the oscillating plate.

maximum speed = ... $m s^{-1}$ **[2]**

(ii) The frequency of the vibrating plate is kept constant and its amplitude is slowly increased from zero. The grains of sand start to lose contact with the plate when the amplitude is A_0. State and explain the necessary conditions when the grains of sand first lose contact with the plate. Hence calculate the value of A_0.

....

....

....

A_0 = ...m **[4]**

(c) The casing of a poorly designed washing machine vibrates violently when the drum rotates during the spin cycle. Fig. 2.2 shows how the amplitude of vibration of the casing varies with the frequency of rotation of the drum.

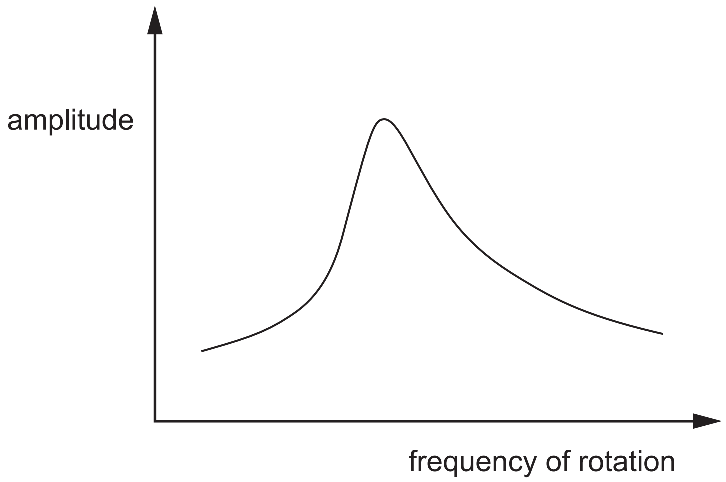


Fig. 2.2

(i) State the name of this effect and describe the conditions under which it occurs.

....

....

....

.... **[2]**

(ii) The design of the washing machine is improved to reduce the effect by adding a damping mechanism to the inside of the machine. Sketch on Fig. 2.2 the new graph of amplitude against frequency of rotation expected for this improved design. **[2]**

[Total: 12]

3 Fig. 3.1 shows apparatus used to investigate circular motion. The bung is attached by a continuous nylon thread to a weight carrier supporting a number of slotted masses which may be varied. The thread passes through a vertical glass tube. The bung can be made to move in a nearly horizontal circle at a steady high speed by a suitable movement of the hand holding the glass tube. A constant radius *r* of rotation can be maintained by the use of a reference mark on the thread.

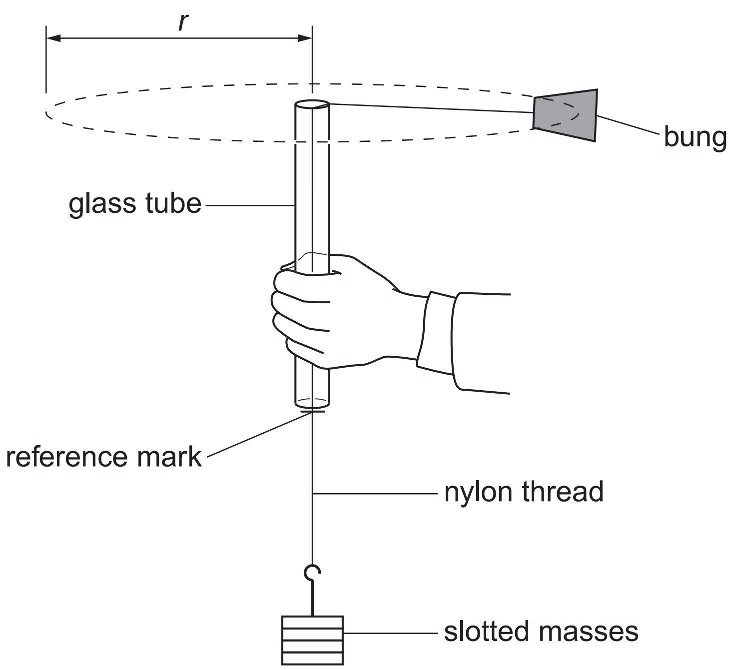


Fig. 3.1

(a) (i) Draw an arrow labelled **F** on Fig. 3.1 to indicate the direction of the resultant force on the bung.

[1]

(ii) Explain how the speed of the bung remains constant even though there is a resultant force *F* acting on it.

....

....

....

....

.... **[2]**

(b) (i) Two students carry out an experiment using the apparatus in Fig. 3.1 to investigate the relationship between the force F acting on the bung and its speed v for a constant radius. Describe how they obtain the values of F and v.

....

....

....

....

....

....

....

....

....

....

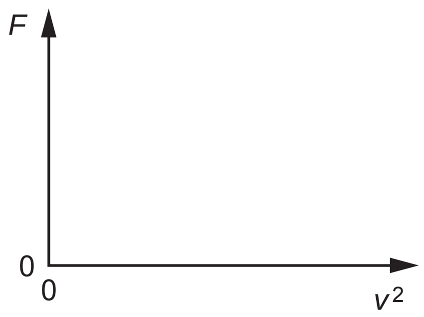
....

....

....

.... **[5]**

(ii) 1 Sketch, on Fig. 3.2, the expected graph of F against v^2.



[1]

Fig. 3.2

2 Explain how the graph can be used to determine the mass m of the bung.

....

....

....

.... **[2]**

[Total: 11]

4 **(a)** **(i)** Define *specific heat capacity*.

....

....

.... **[1]**

(ii) Describe the difference between the *latent heat of fusion* and the *latent heat of vaporisation*.

....

....

.... **[1]**

(b) The graph in Fig. 4.1 shows the variation of temperature with time for a fixed mass of substance when heated by a constant power source. At **A** the substance is a solid; at **E** the substance is a vapour.

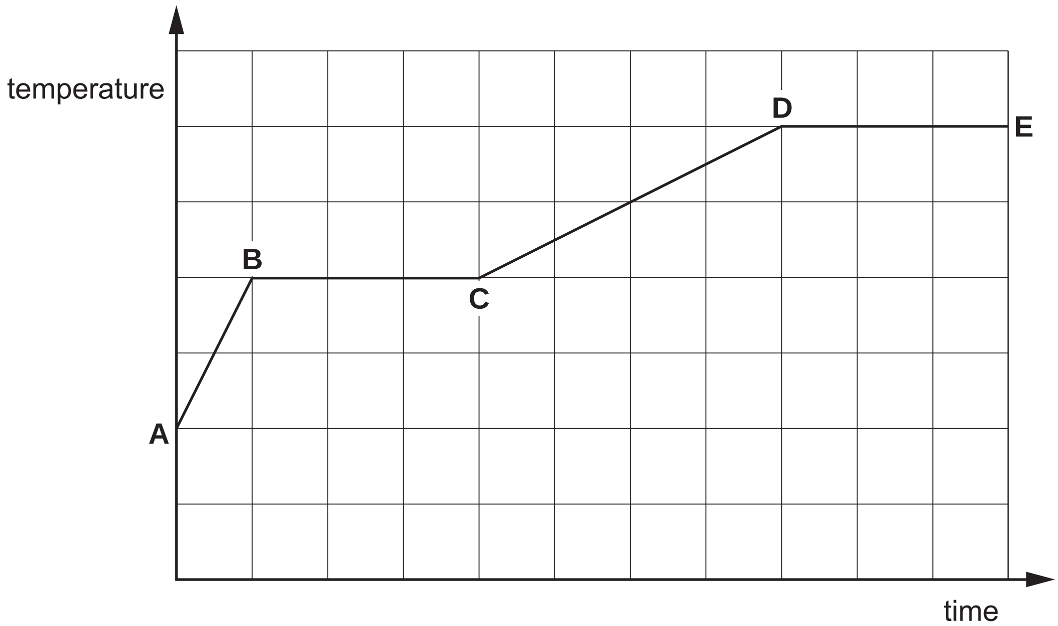


Fig. 4.1

(i) Describe the changes taking place in the kinetic energy and potential energy of the molecules for the following sections:

A to **B**

....

....

....

B to **C**

....

....

.... **[2]**

(ii) State and explain what you can conclude from Fig. 4.1 about the specific heat capacity of the substance in the solid state compared with the specific heat capacity of the substance in the liquid state.

....

....

....

....

.... **[2]**

(c) The electric heating element of a bathroom shower has a power rating of 5.0 kW. An attempt is made to test the accuracy of this value by measuring the rate of flow of the water and the temperature of the water before and after passing the element.

The results of the test and other required data are as follows:

temperature of water supply to the shower = 17.4 °C
temperature of water after being heated by the element = 36.7 °C
rate of flow of water = $3.60 \times 10^{-3}\ \text{m}^3\ \text{min}^{-1}$
density of water = $1000\ \text{kg m}^{-3}$
specific heat capacity of water = $4200\ \text{J kg}^{-1}\ \text{K}^{-1}$

(i) Show that the power of the heating element is approximately 5 kW.

[4]

(ii) State and explain a possible source of uncertainty that might affect the reliability of the test.

....

....

.... **[2]**

[Total: 12]

5 (a) State a conclusion about the movement of gas molecules provided by observations of Brownian motion.

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

....

....

.... **[1]**

(b) Fig. 5.1 shows a gas contained in a cylinder enclosed by a piston. The volume of the gas inside the cylinder is 120 cm^3. The pressure inside the cylinder is 350 kPa.

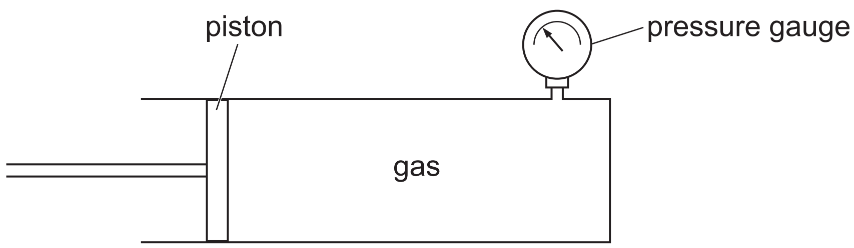


Fig. 5.1

(i) State a necessary condition for Boyle's law to apply to a fixed quantity of gas.

....

....

.... **[1]**

(ii) The piston in Fig. 5.1 is moved quickly so that the gas occupies a volume of 55 cm^3. Use Boyle's law to calculate the new pressure of the gas.

pressure = ………….kPa **[2]**

(iii) In practice, the quick movement of the piston during compression of the gas causes an increase in the temperature of the gas. Explain this increase in temperature in terms of the **movement of the piston** and **the motion of the gas molecules**.

....

....

....

.... **[2]**

[Total: 6]

6 **(a)** **(i)** State Newton's law of gravitation.

....

....

.... **[2]**

(ii) Define *gravitational field strength, g*.

....

.... **[1]**

(b) Titan, a moon of Saturn, has a circular orbit of radius 1.2×10^6 km. The orbital period of Titan is 16 Earth days.

(i) Calculate the speed of Titan in its orbit.

speed = ………………. $m\,s^{-1}$ **[2]**

(ii) Show that the mass of Saturn is about 5×10^{26} kg.

[3]

(c) Rhea is another moon of Saturn with a smaller orbital radius than Titan.
Determine the ratio

$$\frac{\text{orbital period } T_R \text{ of Rhea}}{\text{orbital period } T_T \text{ of Titan}}$$ in terms of their orbital radii r_R, and r_T.

ratio = ……................……… **[2]**

[Total: 10]

END OF QUESTION PAPER

OCR RECOGNISING ACHIEVEMENT

Wednesday 16 January 2013 – Afternoon

A2 GCE PHYSICS A

G484/01 The Newtonian World

Candidates answer on the Question Paper.

OCR supplied materials:
- Data, Formulae and Relationships Booklet (sent with general stationery)

Other materials required:
- Electronic calculator

Duration: 1 hour 15 minutes

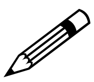
Candidate forename		Candidate surname	

Centre number						Candidate number				

INSTRUCTIONS TO CANDIDATES

- Write your name, centre number and candidate number in the boxes above. Please write clearly and in capital letters.
- Use black ink. HB pencil may be used for graphs and diagrams only.
- Answer **all** the questions.
- Read each question carefully. Make sure you know what you have to do before starting your answer.
- Write your answer to each question in the space provided. Additional paper may be used if necessary but you must clearly show your candidate number, centre number and question number(s).
- Do **not** write in the bar codes.

INFORMATION FOR CANDIDATES

- The number of marks is given in brackets **[ ]** at the end of each question or part question.
- The total number of marks for this paper is **60**.
- You may use an electronic calculator.
- You are advised to show all the steps in any calculations.
-  Where you see this icon you will be awarded marks for the quality of written communication in your answer.
  This means for example you should:
  - ensure that text is legible and that spelling, punctuation and grammar are accurate so that meaning is clear;
  - organise information clearly and coherently, using specialist vocabulary when appropriate.
- This document consists of **16** pages. Any blank pages are indicated.

Turn over

Answer **all** the questions.

1 (a) State, in words, Newton's second law of motion.

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

....

....

.... **[2]**

(b) Fig. 1.1 shows the masses and velocities of two objects **A** and **B** moving directly towards each other. **A** and **B** stick together on impact and move with a common velocity v.

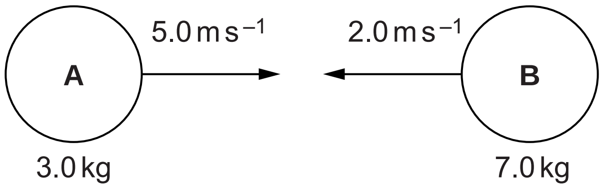


Fig. 1.1

(i) Determine the velocity v.

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

direction = ...
[3]

(ii) Determine the impulse of the force experienced by the object **A** and state its direction.

impulse = ...N s

direction = ...
[2]

(iii) Explain, using Newton's third law of motion, the relationship between the impulse experienced by **A** and the impulse experienced by **B** during the impact.

....

....

....

....

....

.... **[2]**

[Total: 9]

2 A satellite orbits the Earth in a circular path 800 km above the Earth's **surface**. At the orbit of the satellite the gravitational field strength is 7.7 N kg^{-1}. The radius of the Earth is 6400 km.

(a) Calculate

(i) the orbital speed of the satellite

orbital speed = ... m s^{-1} **[3]**

(ii) the period of the orbit of the satellite.

period = ... s **[2]**

(b) The orbit of the satellite passes over the Earth's poles.

(i) Show that the satellite makes about 14 orbits around the Earth in 24 hours.

[1]

(ii) The cameras on board the satellite continually photograph a strip of the Earth's surface, of width 3000 km, directly below the satellite. Determine, with an appropriate calculation, whether the satellite can photograph the whole of the Earth's surface in 24 hours. State your conclusion.

....

....

.... **[3]**

(c) Suggest a practical use of such a satellite.

....

.... **[1]**

[Total: 10]

3 **(a)** State, in words, Newton's law of gravitation.

....

....

.... **[1]**

(b) Fig. 3.1 shows the circular orbits of two of Jupiter's moons: Adrastea, **A**, and Megaclite, **M**.

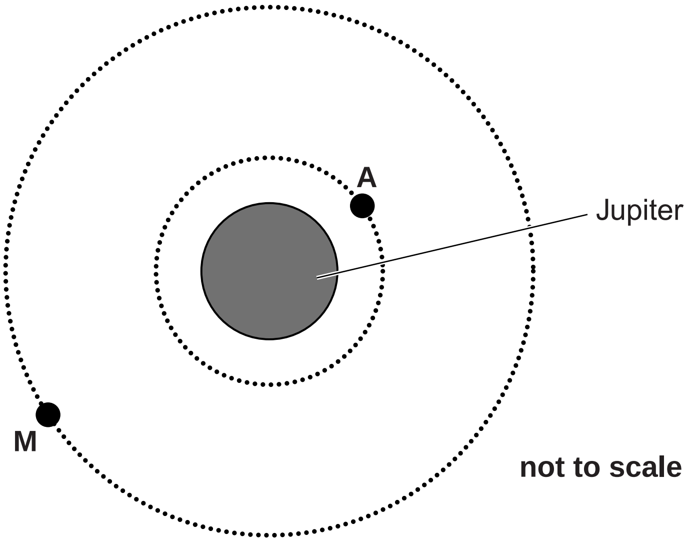


Fig. 3.1

Use the following data in the calculations below.

orbital radius of **A** = 1.3×10^8 m
orbital period of **A** = 7.2 hours
gravitational field strength at orbit of **A** = 7.5 N kg^{-1}
orbital radius of **M** = 2.4×10^{10} m

Calculate

(i) the mass of Jupiter

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

(ii) the gravitational field strength at the orbit of **M**

gravitational field strength = ... $N\,kg^{-1}$ **[2]**

(iii) the orbital period of **M**.

orbital period = ... hours **[3]**

[Total: 9]

4 Fig. 4.1 shows slotted masses suspended from a spring. The spring is attached to a fixed support at its upper end.

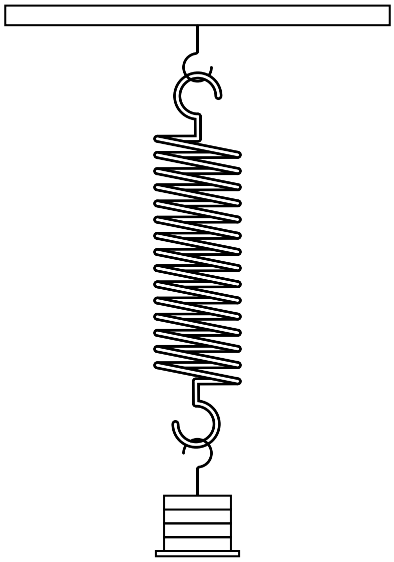


Fig. 4.1

When the masses are pulled down a short distance from the equilibrium position and released they oscillate vertically with simple harmonic motion. The frequency f of these oscillations depends on the mass m of the masses.
Two students make different predictions about the relationship between f and m.
One suggests f is proportional to $1/m$ and the other believes f is proportional to $1/\sqrt{m}$.

(a) Describe how you would test experimentally which prediction is correct.
Include in your answer:

- the measurements you would take, and
- how you would use these measurements to test each prediction.

You should also discuss ways of making the test as reliable as possible.

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.... **[4]**

(b) When the masses hanging on the spring are 400 g in total, they oscillate with an amplitude of 36 mm and a period of 1.2 s. Calculate

(i) the maximum kinetic energy of the masses

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

(ii) the maximum acceleration of the masses.

maximum acceleration = ... $m\,s^{-2}$ **[2]**

(c) List the different types of energy involved in the oscillations of this mass-spring system. Describe the energy changes when the masses move from the lowest point of the oscillation to the highest point.

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

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.... **[4]**

[Total: 13]

5 **(a)** **(i)** The pressure p and volume V of a quantity of an ideal gas at absolute temperature T are related by the equations $pV = nRT$ and $pV = NkT$. In these equations identify the symbols n and N.

n ....

N.. **[1]**

(ii) Choose one of the equations in **(i)** and show how Boyle's law follows from it.

....

....

.... **[2]**

(iii) Show that the product of pV has the same units as work done.

[1]

(b) The graph in Fig. 5.1 shows the variation of pressure, p, with the reciprocal of volume, $1/V$, of 0.050 kg of oxygen behaving as an ideal gas.

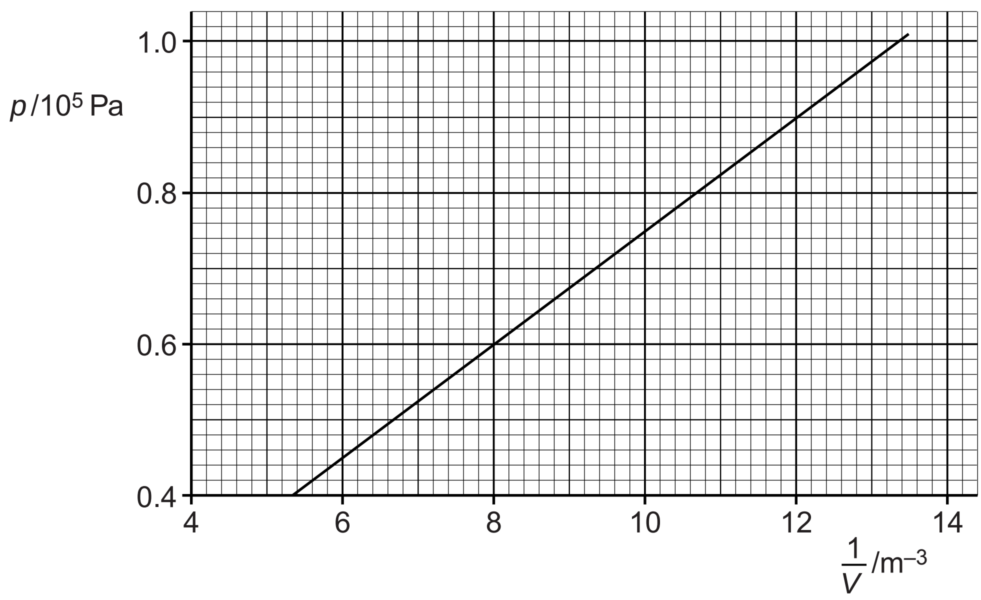

Fig. 5.1

(i) Use the graph to show that the variation of p with $\frac{1}{V}$ is taking place at constant temperature.

[2]

(ii) The molar mass of oxygen is 0.016 kg mol^{-1}. Calculate the temperature, in °C, of the oxygen in **(i)**.

temperature = ... °C **[3]**

[Total: 9]

6 **(a)** Describe

(i) the motion of atoms in a solid at a temperature well below its melting point

....

.... **[1]**

(ii) the effect of a small increase in temperature on the motion of these atoms

....

.... **[1]**

(iii) the effect on the internal energy and temperature of the solid when it melts.

....

....

.... **[2]**

(b) Fig. 6.1 shows the apparatus used to determine the specific heat capacity of a metal. A block made of the metal is heated by an electrical heater that produces a constant power of 48 W. In order to reduce heat loss from the sides, top and bottom of the block, it is covered by a layer of insulating material.

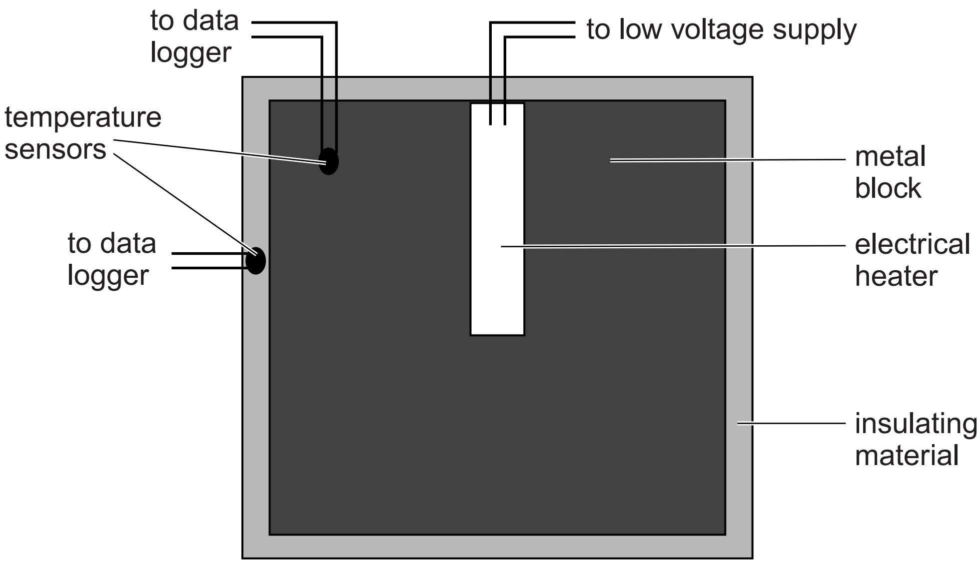

Fig. 6.1

Temperature sensors connected to a data logger show that the block and insulation are initially at the room temperature of 18 °C. The heater is switched on and after 720 seconds the sensors show that the temperature of the block is 54 °C and the average temperature of the insulating material is 38 °C.

(i) Use the information given above and the data shown below to determine the specific heat capacity of the metal block.

mass of metal block = 0.98 kg
power of heater = 48 W
specific heat capacity of the insulating material = 850 J kg^{-1} K^{-1}
mass of the insulating material = 0.027 kg

specific heat capacity = ... J kg^{-1} K^{-1} **[4]**

(ii) A second experiment is done without the insulating material and with the block again starting at 18 °C. Discuss whether the value of the specific heat capacity calculated from the second experiment is likely to be lower, the same or higher than the value calculated in **(i)**.

....

....

....

.... **[2]**

[Total: 10]

END OF QUESTION PAPER

Data

Values are given to three significant figures, except where more are useful.

speed of light in a vacuum	c	3.00×10^{8} m s^{-1}
permittivity of free space	ε_0	8.85×10^{-12} C^{2} N^{-1} m^{-2} (F m^{-1})
elementary charge	e	1.60×10^{-19} C
Planck constant	h	6.63×10^{-34} J s
gravitational constant	G	6.67×10^{-11} N m^{2} kg^{-2}
Avogadro constant	N_A	6.02×10^{23} mol^{-1}
molar gas constant	R	8.31 J mol^{-1} K^{-1}
Boltzmann constant	k	1.38×10^{-23} J K^{-1}
electron rest mass	m_e	9.11×10^{-31} kg
proton rest mass	m_p	1.673×10^{-27} kg
neutron rest mass	m_n	1.675×10^{-27} kg
alpha particle rest mass	m_α	6.646×10^{-27} kg
acceleration of free fall	g	9.81 m s^{-2}

Conversion factors

unified atomic mass unit	$1\ \text{u} = 1.661 \times 10^{-27}\ \text{kg}$
electron-volt	$1\ \text{eV} = 1.60 \times 10^{-19}\ \text{J}$
	$1\ \text{day} = 8.64 \times 10^{4}\ \text{s}$
	$1\ \text{year} \approx 3.16 \times 10^{7}\ \text{s}$
	$1\ \text{light year} \approx 9.5 \times 10^{15}\ \text{m}$

Mathematical equations

arc length = $r\theta$

circumference of circle = $2\pi r$

area of circle = πr^2

curved surface area of cylinder = $2\pi rh$

volume of cylinder = $\pi r^2 h$

surface area of sphere = $4\pi r^2$

volume of sphere = $\frac{4}{3}\pi r^3$

Pythagoras' theorem: $a^2 = b^2 + c^2$

For small angle $\theta \Rightarrow \sin\theta \approx \tan\theta \approx \theta$ and $\cos\theta \approx 1$

$\lg(AB) = \lg(A) + \lg(B)$

$\lg(\frac{A}{B}) = \lg(A) - \lg(B)$

$\ln(x^n) = n \ln(x)$

$\ln(e^{kx}) = kx$

Formulae and relationships

Unit 1 – Mechanics

$F_x = F\cos\theta$
$F_y = F\sin\theta$

$a = \dfrac{\Delta v}{\Delta t}$

$v = u + at$

$s = \dfrac{1}{2}(u + v)t$

$s = ut + \dfrac{1}{2}at^2$

$v^2 = u^2 + 2as$

$F = ma$

$W = mg$

moment = Fx

torque = Fd

$\rho = \dfrac{m}{V}$

$p = \dfrac{F}{A}$

$W = Fx\cos\theta$

$E_k = \dfrac{1}{2}mv^2$

$E_p = mgh$

efficiency = $\dfrac{\text{useful energy output}}{\text{total energy input}} \times 100\%$

$F = kx$

$E = \dfrac{1}{2}Fx \qquad E = \dfrac{1}{2}kx^2$

stress = $\dfrac{F}{A}$

strain = $\dfrac{x}{L}$

Young modulus = $\dfrac{\text{stress}}{\text{strain}}$

Unit 2 – Electrons, Waves and Photons

$\Delta Q = I\Delta t$

$I = Anev$

$W = VQ$

$V = IR$

$R = \dfrac{\rho L}{A}$

$P = VI \qquad P = I^2R \qquad P = \dfrac{V^2}{R}$

$W = VIt$

e.m.f. = $V + Ir$

$V_{out} = \dfrac{R_2}{R_1 + R_2} \times V_{in}$

$v = f\lambda$

$\lambda = \dfrac{ax}{D}$

$d\sin\theta = n\lambda$

$E = hf \qquad E = \dfrac{hc}{\lambda}$

$hf = \phi + KE_{max}$

$\lambda = \dfrac{h}{mv}$

$R = R_1 + R_2 + \ldots$

$\dfrac{1}{R} = \dfrac{1}{R_1} + \dfrac{1}{R_2} + \ldots$

Unit 4 – Newtonian World

$F = \frac{\Delta p}{\Delta t}$

$v = \frac{2\pi r}{T}$

$a = \frac{v^2}{r}$

$F = \frac{mv^2}{r}$

$F = -\frac{GMm}{r^2}$

$g = \frac{F}{m}$

$g = -\frac{GM}{r^2}$

$T^2 = \left(\frac{4\pi^2}{GM}\right)r^3$

$f = \frac{1}{T}$

$\omega = \frac{2\pi}{T} = 2\pi f$

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

$x = A \cos(2\pi ft)$

$v_{max} = (2\pi f) A$

$E = mc\Delta\theta$

$pV = NkT$

$pV = nRT$

$E = \frac{3}{2} kT$

Unit 5 – Fields, Particles and Frontiers of Physics

$E = \frac{F}{Q}$

$F = \frac{Qq}{4\pi\varepsilon_0 r^2}$

$E = \frac{Q}{4\pi\varepsilon_0 r^2}$

$E = \frac{V}{d}$

$F = BIL \sin\theta$

$F = BQv$

$\phi = BA \cos\theta$

induced e.m.f. = – rate of change of magnetic flux linkage

$\frac{V_s}{V_p} = \frac{n_s}{n_p}$

$Q = VC$

$W = \frac{1}{2} QV \qquad W = \frac{1}{2} CV^2$

time constant = CR

$x = x_0 e^{-\frac{t}{CR}}$

$C = C_1 + C_2 + \dots$

$\frac{1}{C} = \frac{1}{C_1} + \frac{1}{C_2} + \dots$

$A = \lambda N$

$A = A_0 e^{-\lambda t}$

$N = N_0 e^{-\lambda t}$

$\lambda t_{½} = 0.693$

$\Delta E = \Delta mc^2$

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