THIS IS A LEGACY SPECIFICATION

OCR
RECOGNISING ACHIEVEMENT

**ADVANCED GCE**

# PHYSICS A

Unifying Concepts in Physics

**2826/01**

Candidates answer on the question paper

**OCR Supplied Materials:**
None

**Other Materials Required:**
- Electronic calculator

**Wednesday 10 June 2009**
**Afternoon**

**Duration:** 1 hour 15 minutes

*CUP/T61217*

*2826 01*

| Candidate Forename | | Candidate Surname | |
|---|---|---|---|

| Centre Number | | | | | | Candidate Number | | | | |
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**INSTRUCTIONS TO CANDIDATES**

- Write your name clearly in capital letters, your Centre Number and Candidate Number in the boxes above.
- Use black ink. Pencil may be used for graphs and diagrams only.
- Read each question carefully and make sure that you know what you have to do before starting your answer.
- Answer **all** the questions.
- Do **not** write in the bar codes.
- Write your answer to each question in the space provided, however additional paper may be used if necessary.

**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.
- This document consists of **16** pages. Any blank pages are indicated.

| FOR EXAMINER'S USE | | |
|---|---|---|
| **Qu.** | **Max.** | **Mark** |
| **1** | **16** | |
| **2** | **14** | |
| **3** | **10** | |
| **4** | **10** | |
| **5** | **10** | |
| **TOTAL** | **60** | |

**Data**

| | |
|---|---|
| speed of light in free space, | $c = 3.00 \times 10^{8}\ \mathrm{m\,s^{-1}}$ |
| permeability of free space, | $\mu_0 = 4\pi \times 10^{-7}\ \mathrm{H\,m^{-1}}$ |
| permittivity of free space, | $\epsilon_0 = 8.85 \times 10^{-12}\ \mathrm{F\,m^{-1}}$ |
| elementary charge, | $e = 1.60 \times 10^{-19}\ \mathrm{C}$ |
| the Planck constant, | $h = 6.63 \times 10^{-34}\ \mathrm{J\,s}$ |
| unified atomic mass constant, | $u = 1.66 \times 10^{-27}\ \mathrm{kg}$ |
| rest mass of electron, | $m_e = 9.11 \times 10^{-31}\ \mathrm{kg}$ |
| rest mass of proton, | $m_p = 1.67 \times 10^{-27}\ \mathrm{kg}$ |
| molar gas constant, | $R = 8.31\ \mathrm{J\,K^{-1}\,mol^{-1}}$ |
| the Avogadro constant, | $N_A = 6.02 \times 10^{23}\ \mathrm{mol^{-1}}$ |
| gravitational constant, | $G = 6.67 \times 10^{-11}\ \mathrm{N\,m^2\,kg^{-2}}$ |
| acceleration of free fall, | $g = 9.81\ \mathrm{m\,s^{-2}}$ |

**Formulae**

uniformly accelerated motion, $s = ut + \frac{1}{2}at^2$

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

refractive index, $n = \frac{1}{\sin C}$

capacitors in series, $\frac{1}{C} = \frac{1}{C_1} + \frac{1}{C_2} + \ldots$

capacitors in parallel, $C = C_1 + C_2 + \ldots$

capacitor discharge, $x = x_0 e^{-t/CR}$

pressure of an ideal gas, $p = \frac{1}{3}\frac{Nm}{V}\langle c^2 \rangle$

radioactive decay, $x = x_0 e^{-\lambda t}$

$t_{\frac{1}{2}} = \frac{0.693}{\lambda}$

critical density of matter in the Universe, $\rho_0 = \frac{3H_0^2}{8\pi G}$

relativity factor, $= \sqrt{(1 - \frac{v^2}{c^2})}$

current, $I = nAve$

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

sound intensity level, $= 10 \lg \left(\frac{I}{I_0}\right)$

Answer **all** the questions.

**1** Conservation laws are used in physics in many different situations. In this question you are asked to state three conservation laws and then to explain how some other laws can be regarded as conservation laws.

**(a)** State **three** conservation laws.

1. The law of conservation of ..... states that .....

.....

..... **[1]**

2. The law of conservation of ..... states that .....

.....

..... **[1]**

3. The law of conservation of ..... states that .....

.....

..... **[1]**

**(b)** Each of the following examples follows from a conservation law. In each case state what is being conserved and explain how each demonstrates conservation.

**(i)** Kirchhoff's first law states that – the sum of the electric currents into any point in an electrical circuit equals the sum of the currents out of the point.

The conserved quantity is .....

Explanation .....

.....

..... **[3]**

**(ii)** Kirchhoff's second law states that – the sum of the electromotive forces (e.m.f.s) around any loop in a circuit is equal to the sum of the potential differences (p.d.s) around the loop.

The conserved quantity is .....

Explanation .....

.....

.....

..... **[3]**

**(iii)** When a cannon fired a cannonball the cannon recoiled.

The conserved quantity is .....

Explanation .....

.....

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..... **[3]**

**(iv)** The Earth continually receives electromagnetic radiation from the Sun but its mean temperature stays almost constant over a period of a few years.

The conserved quantity is .....

Explanation .....

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..... **[4]**

**[Total: 16]**

**2** This question asks you to consider the force a space cabin exerts on an astronaut from take off until the cabin is docked alongside the International Space Station (ISS). The ISS is in a permanent orbit of radius $6.71 \times 10^6$ m around the Earth. The radius of the Earth is $6.37 \times 10^6$ m.
The graph in Fig. 2.1 shows how the **magnitude** of the force the cabin exerts on the astronaut varies over a period of time from just before blast off until docking takes place. Fig. 2.2 shows how the gravitational field strength, *g*, of the Earth varies with distance from the Earth's surface.

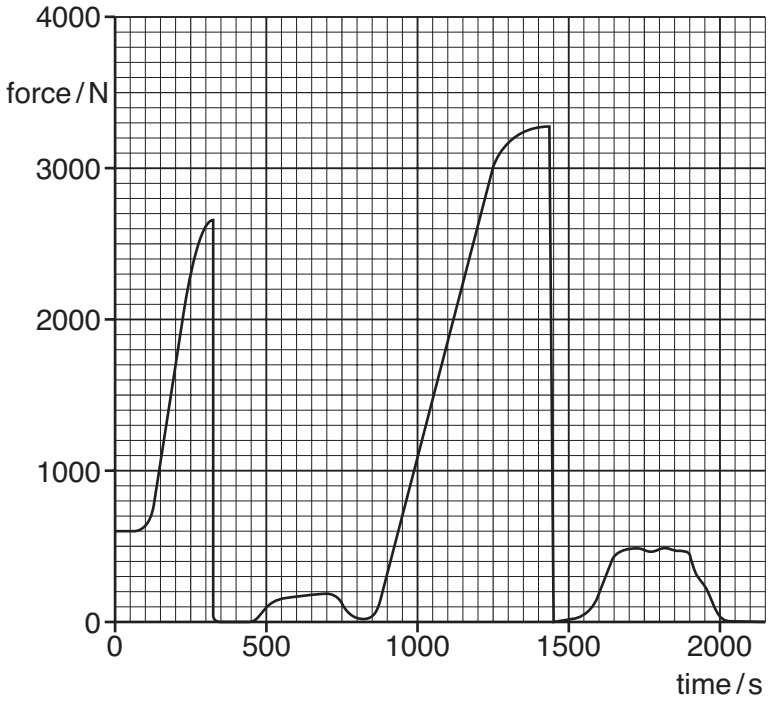


**Fig. 2.1**

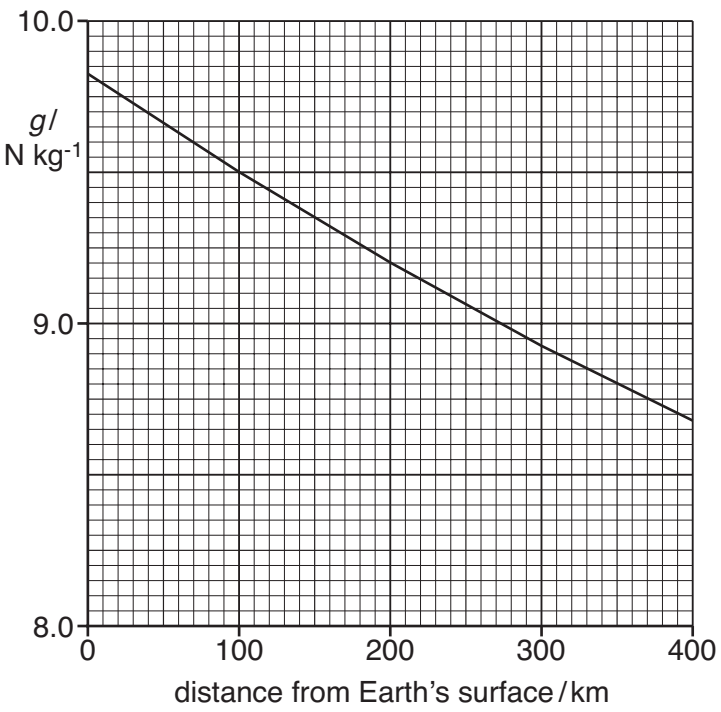


**Fig. 2.2**

**(a)** Use the graphs to determine

**(i)** the mass of the astronaut

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

**(ii)** the maximum force applied to the astronaut

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

**(iii)** the pull of the Earth on the astronaut when 200 km from the Earth's surface.

pull of Earth at 200 km = ..... N **[2]**

**(b)** Explain why

**(i)** the rocket does not produce a constant acceleration even when the thrust is constant

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

**(ii)** the area under the force–time graph, of Fig. 2.1, will not equal the increase in the momentum of the astronaut.

.....

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

**(c)** Show that the value of the centripetal acceleration of the ISS is $8.83\,m\,s^{-2}$.

**[1]**

**(d)** Calculate

**(i)** the speed of the ISS

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

**(ii)** the kinetic energy of the astronaut as she circles the Earth in the ISS.

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

**[Total: 14]**

**3** The photograph in Fig 3.1 shows the Millau viaduct, carrying traffic across the Tarn Gorge in the south of France. It has seven pillars, each supporting a pylon similar to the one shown in the diagram in Fig. 3.2.

**Fig. 3.1**

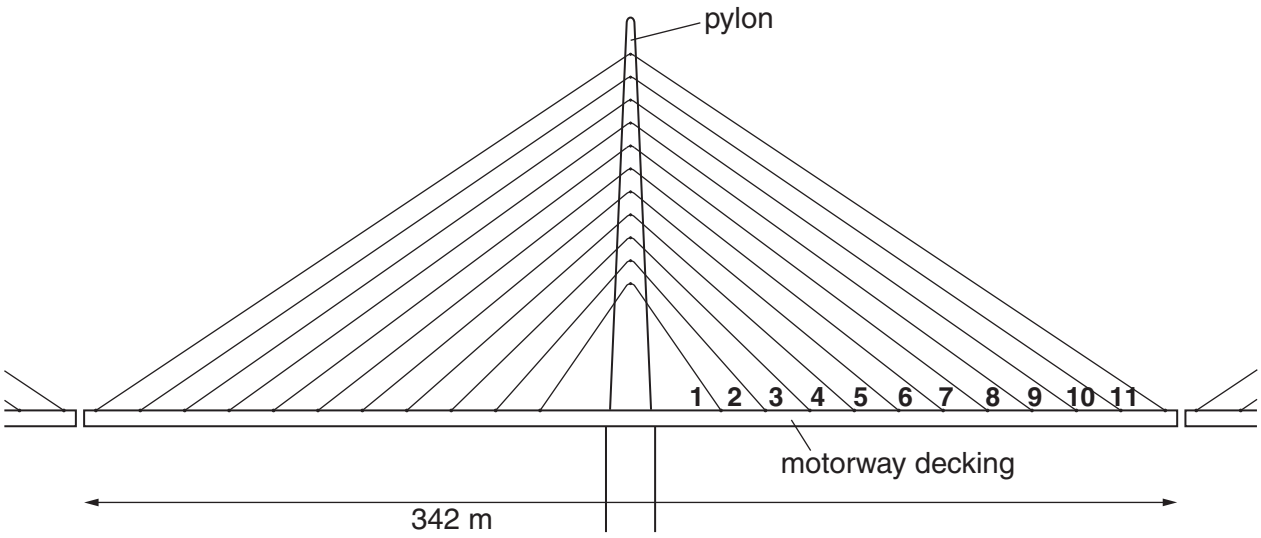


**Fig. 3.2**

Each of the pylons has 11 cables passing through them to support motorway decking of length 342 m. The cables are attached to the decking at equal distances along the motorway.
The chart of Fig. 3.3 shows the maximum tension in each of the cables for different angles of cables to the vertical.

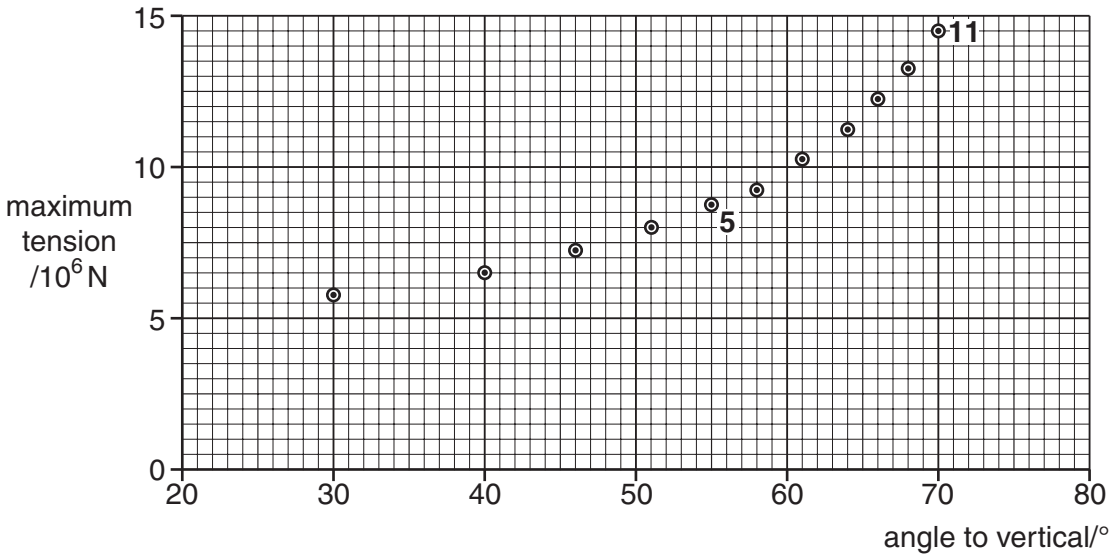


**Fig. 3.3**

**(a)** Show that the maximum vertical support force which can be provided by cables **5** and **11** are the same.

vertical support provided by cable **5** = ..... N

vertical support provided by cable **11** = ..... N **[2]**

**(b)** Given that all cables provide the same maximum vertical support force, calculate the maximum upward force that needs to be provided by each pylon.

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

**(c)** Some forces of loading on the viaduct are **constant** and easy to calculate, but other forces are **variable** and are much more difficult to determine. Describe **two** examples of each of these two types of force that had to be considered in the design of the viaduct. In your answer explain why it is difficult to determine the maximum possible loading on each pylon.

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..... **[6]**

**[Total: 10]**

**4** **(a)** The Einstein equation for the photoelectric effect is

$$hf = \phi + \tfrac{1}{2}mv^2_{max}.$$

**(i)** Describe the situation to which this equation applies.

.....

.....

.....

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

**(ii)** State the **meaning** of each of the three terms in the equation.

$hf$ is .....

$\phi$ is .....

.....

$\tfrac{1}{2}mv^2_{max}$ is .....

..... **[3]**

**(iii)** Suggest why photoelectrons have a range of kinetic energies.

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.....

..... **[1]**

**(b)** Fig. 4.1 shows the apparatus used in 1897 by J.J.Thomson. It was a vacuum tube in which cathode rays travelled from a negative cathode to a positive anode.

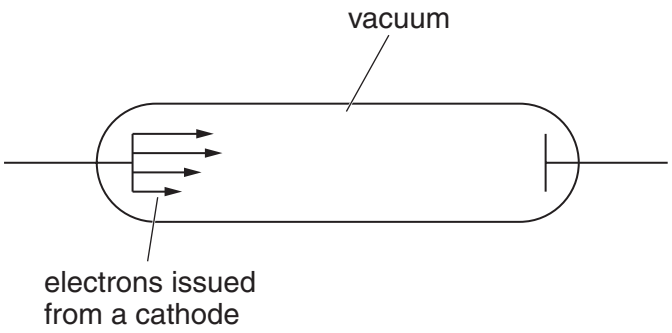


**Fig 4.1**

Thomson discovered that the rays were streams of particles, that are now called electrons.

Given a piece of apparatus similar to Thomson's, and other standard apparatus of your choice, describe with a diagram an experiment to measure the maximum kinetic energy of electrons in the stream.

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..... **[4]**

**[Total: 10]**

**5** State where the physics is incorrect in the following statements made by people talking about energy saving measures. Explain the mistake and suggest how each statement may be changed to make it correct.

**(a)** "By introducing these measures the council will save 20 MW annually."

mistake .....

.....

suggested alteration .....

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

**(b)** "The wind generators will supply all the electricity required for 200 houses."

mistake .....

.....

suggested alteration .....

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

**(c)** "Rivers should have mini-hydroelectricity generators every few hundred metres along their length so that each one can contribute free electrical power to the National Grid."

mistake .....

.....

suggested alteration .....

..... **[3]**

**(d)** "If, in order to produce hydroelectricity, a barrage across the river estuary is ever built, the stopping of tides behind the barrage would destroy the feeding grounds for large flocks of sea birds."

mistake .....

.....

suggested alteration .....

..... **[3]**

**[Total: 10]**

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