Centre Number

71

Candidate Number

Rewarding Learning

ADVANCED
General Certificate of Education
2011

Physics

Assessment Unit A2 1

assessing

Momentum, Thermal Physics, Circular Motion, Oscillations and Atomic and Nuclear Physics

[AY211]

AY211

TUESDAY 24 MAY, MORNING

TIME

1 hour 30 minutes.

INSTRUCTIONS TO CANDIDATES

Write your Centre Number and Candidate Number in the spaces provided at the top of this page.
Answer **all** questions.
Write your answers in the spaces provided in this question paper.

INFORMATION FOR CANDIDATES

The total mark for this paper is 90.
Quality of written communication will be assessed in question **2**.
Figures in brackets printed down the right-hand side of pages indicate the marks awarded to each question.
Your attention is drawn to the Data and Formulae Sheet which is inside this question paper.
You may use an electronic calculator.
Question **9** contributes to the synoptic assessment required of the specification.

For Examiner's use only	
Question Number	Marks
1	
2	
3	
4	
5	
6	
7	
8	
9	
Total Marks	

Examiner Only	
Marks	Remark

If you need the values of physical constants to answer any questions in this paper they may be found in the Data and Formulae sheet.

Answer all **nine** questions

1 (a) State the principle of conservation of momentum.

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____

____ [2]

(b) A trolley of mass 0.8 kg has a velocity 0.4 m s^{-1} to the right. It collides head on and sticks to another trolley of mass 0.6 kg which is moving with a velocity 0.3 m s^{-1} in the opposite direction as illustrated in **Fig.1.1**. During the collision some energy is converted into heat and sound.

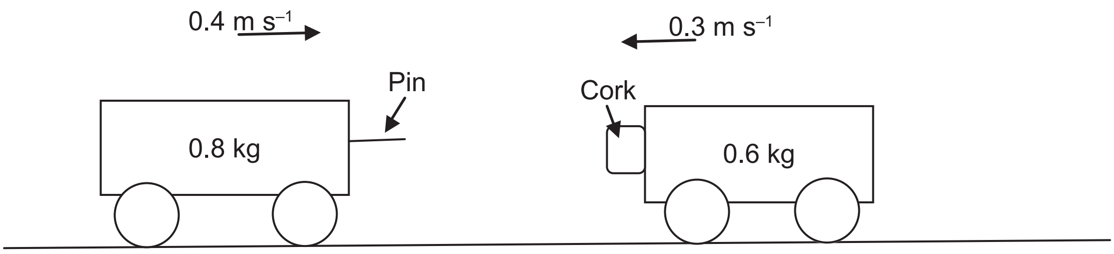

Fig. 1.1

(i) Calculate the magnitude and direction of the velocity of the trolleys after the collision.

Velocity = ____________ m s^{-1}

Direction: To the ____________ [3]

(ii) Is this an example of an elastic or an inelastic collision? Explain your answer.

____

____ [2]

2 Your answer to part (a)(ii) of this question should be in continuous prose. You will be assessed on the quality of your written communication.

Examiner Only	
Marks	Remark

(a) (i) A student gives the following incomplete statement of one of the laws for an ideal gas:

"The volume of an ideal gas is inversely proportional to the pressure applied to it."

Identify two important omissions from the correct and complete version of this statement.

1. ____

2. ____ [2]

(ii) Describe an experiment to investigate the law referred to in **(i)**. Include a labelled diagram in the space below. Indicate how you would process your results to clearly demonstrate the relationship between pressure and volume.

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____ [6]

Quality of written communication [2]

(b) The air pressure inside a car tyre is 280 kPa at a temperature of 15 ºC. After a journey the pressure rises to 310 kPa. Assuming the volume of air remains constant, calculate the new temperature of the air in the tyre.

Temperature = ___________ ºC [2]

Examiner Only	
Marks	Remark

3 **(a)** The radius of the Earth at the equator is 6.38×10^6 m. The Earth rotates with a period of 24.0 hours.

Examiner Only	
Marks	Remark

(i) Calculate the angular velocity of a point on the equator.

Angular velocity = ___________ rad s^{-1} [2]

(ii) Calculate the linear velocity at a point on the equator.

Velocity = ___________ m s^{-1} [2]

(iii) A student of mass 74.2 kg stands at a point on the equator. Calculate the magnitude of the centripetal force acting on the student.

Centripetal force = ___________ N [2]

(b) Gravity provides a pull on the student towards the centre of the Earth. The magnitude of this force is 728 N. The student measures his weight when at the equator. Will the value obtained be 728 N or more or less than 728 N? Explain your answer.

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____ [2]

4 **(a)** A body executes simple harmonic motion in a straight line.

Fig. 4.1.1 is a graph of the body's displacement x, from its equilibrium position, against time t.

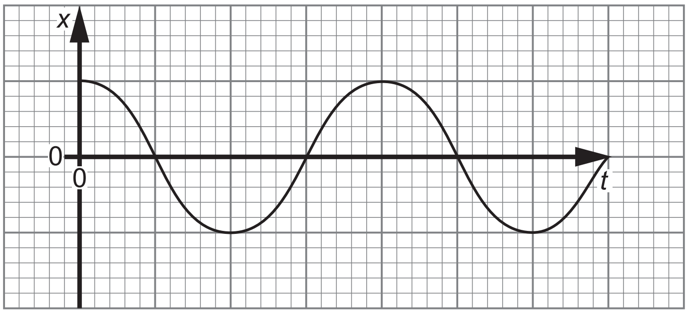

Fig. 4.1.1

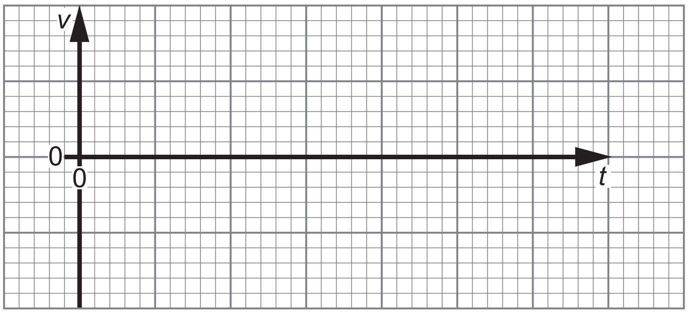

Fig. 4.1.2

(i) On **Fig. 4.1.2** sketch a graph of the body's velocity v against time t.

(ii) State the phase difference between your graph in **Fig. 4.1.2** and the graph in **Fig. 4.1.1**.

Phase difference ____________ [2]

(b) Explain what is meant by each of the following terms:

(i) free vibration ____

____

(ii) forced vibration ____

____ [2]

Examiner Only	
Marks	Remark

(c) (i) A mechanical system which is undergoing forced vibrations may show **resonance**. Explain briefly what must happen for the forced vibration to produce resonance.

____

____ [1]

(ii) Give an example of a mechanical system which can be made to resonate and describe briefly how damping is achieved.

____

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____ [2]

(iii) On **Fig. 4.2** sketch two curves to illustrate how the amplitude of such a vibrating system varies with frequency when the damping is light (labelled **A**) and when the damping is heavier (labelled **B**).

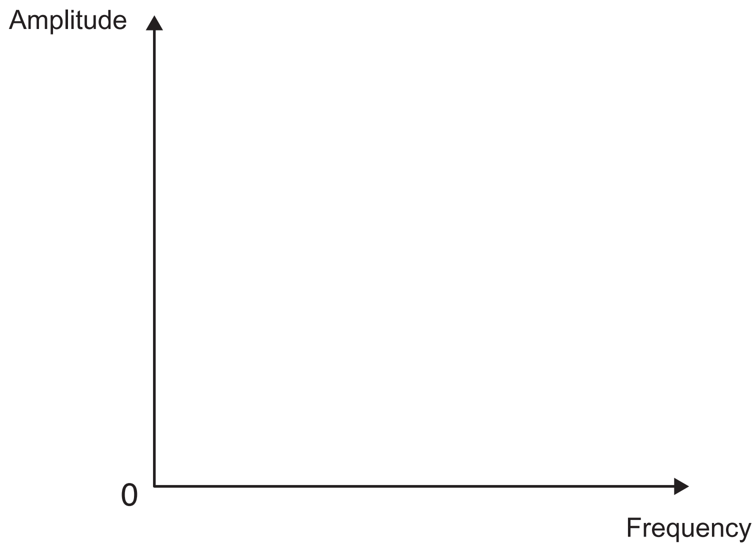

Fig. 4.2

[3]

Examiner Only	
Marks	Remark

5 **(a)** In an experiment to investigate the structure of the atom, a fine beam of alpha particles was directed at a thin gold foil in a vacuum. Describe the **results** of this experiment and explain how they lead to the conclusion that the atom has a positive charge concentrated in a very small core (known as the nucleus)

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____ [2]

(b) Your data and formulae sheet gives the equation for the radius of a nucleus as

$$r = r_0 A^{\frac{1}{3}}$$ **Equation 5.1**

(i) In equation **5.1** what does the symbol *A* represent?

____ [1]

(ii) In terms of protons, neutrons and electrons, describe the structure of an atom of lithium-7 ($^{7}_{3}Li$).

____

____ [2]

(iii) Use equation **5.1** to find the radius of a lithium-7 nucleus. Take r_0 = 1.2 fm.

Radius = ____________ m [2]

Examiner Only	
Marks	Remark

(iv) Hence find the density of a lithium-7 nucleus.
(Mass of a lithium-7 nucleus 7.014 u, sphere volume = $\frac{4}{3}\pi r^3$.)

Examiner Only	
Marks	Remark

Density = ___________ kg m^{-3}. [3]

Examiner Only	
Marks	Remark

6 **(a)** Describe an experiment to measure the half-life of a radioactive isotope. Your description should include a list of readings to be taken, any necessary safety precautions and how the results are to be processed to find the half-life of the isotope.

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____ [6]

(b) The half-life of cobalt-60, a typical laboratory γ-source, is 5.26 years. What mass of cobalt-60 will have an activity of 8.72×10^5 Bq? Take the mass of a cobalt-60 atom to be 9.96×10^{-26} kg.

Mass = ____________ kg [4]

7 **(a)** A camera battery is charged at 4.2 V, 0.7 A for 90 minutes. This results in a transfer of energy. Use the Einstein mass-energy relationship to find the small mass increase of the battery.

Examiner Only	
Marks	Remark

Mass increase = ___________ kg [3]

(b) One example of the fission of U-235 is the following reaction:

$$^{235}_{92}U + ^{1}_{0}n \longrightarrow ^{140}_{55}Cs + ^{93}_{37}Rb + 3\,^{1}_{0}n + \text{energy}$$

(i) Calculate the amount of energy released in this reaction.

Mass of U-235 atom = 235.04394 u

Mass of Cs-140 atom = 139.91728 u

Mass of Rb-93 atom = 92.92204 u

Mass of a neutron = 1.008665 u

Energy released = ___________ J [3]

(ii) Estimate the theoretical maximum energy released if 1 kg of uranium-235 underwent fission by this route.

Energy released = ___________ J [3]

8 Nuclear fusion could replace fossil fuels as an energy resource on the Earth.

(a) One reaction which could lead to the release of energy is the fusion of deuterium and tritium (the D-T reaction).

(i) Give the equation for the D-T reaction.

____ [1]

(ii) Give **two** reasons why this reaction is most suitable for terrestrial fusion.

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____

____ [2]

(b) (i) The JET fusion reactor has been designed to produce the required conditions for fusion to take place.

Outline the basic principles of its operation.

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____ [3]

(ii) Explain why it is difficult to achieve fusion in the JET fusion reactor.

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____

____ [2]

Examiner Only	
Marks	Remark

Examiner Only	
Marks	Remark

9 Data Analysis Question

This question contributes to the synoptic question requirement of the specification. In your answer you will be expected to bring together and apply principles and concepts from different areas of physics, and to use the skills of physics in the particular situation described.

Waves in strings

Musical string instruments such as guitars and pianos contain strings, often made of metal wires, which when stimulated resonate at frequencies which are governed by three factors:

1. the vibrating length of the wire, l

2. the mass per unit length of the wire, μ

3. the tension of the wire, T

These factors are related to the lowest resonant frequency of vibration f by **Equation 9.1**:

$$f = \frac{1}{2l}\left(\frac{T}{\mu}\right)^n \qquad \textbf{Equation 9.1}$$

(a) A student sets up an experiment to find the value of n. She used a steel wire of vibrating length 0.60 m. This wire had mass per unit length equal to 3.30×10^{-4} kg m^{-1}. **Fig. 9.1** shows the arrangement. The vibrator was connected to a signal generator and the lowest frequency at which resonance occurred was recorded for various tensions. The tension is produced in the wire by attaching weights to the end of the wire.

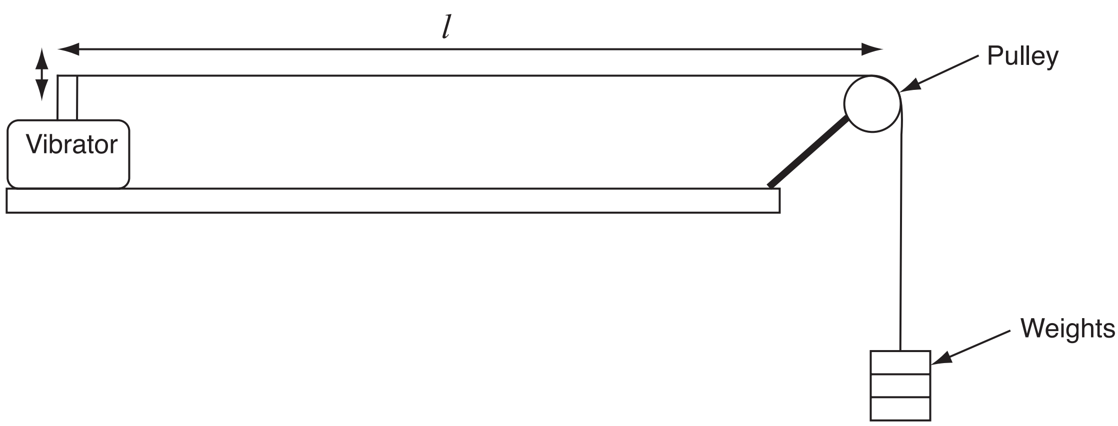

Fig. 9.1

Table 9.1 shows the values of the lowest resonant frequency *f*, obtained for various values of string tension *T*.

Examiner Only	
Marks	Remark

Table 9.1

f/Hz	T/N	$(\frac{T}{\mu})$/N m kg^{-1}	$\lg_{10}$ (f/Hz)	$\lg_{10}$ [$(\frac{T}{\mu})$/N m kg^{-1}]
178	15.0			
229	25.0			
271	35.0			
308	45.0			
340	55.0			
370	65.0			

(i) Complete **Table 9.1** by calculating the values for the three headed columns. [3]

(ii) On **Fig. 9.2** plot the graph $\lg_{10}$ (f/Hz) against $\lg_{10}$ [$(\frac{T}{\mu})$/N m kg^{-1}] from which you will be able to obtain a value for *n*. Draw the best straight line through the points. [5]

Examiner Only	
Marks	Remark

Fig 9.2

Examiner Only	
Marks	Remark

(iii) Use your graph to calculate a value for *n*.

n = ___________ [3]

(iv) The mass per unit length μ is calculated by dividing the mass of the wire by its length. Show that the mass per unit length is also equal to the cross-sectional area of the wire multiplied by its density.

[1]

(v) The density of the wire used in her investigation was 7700 kg m^{-3}.

Use this value and the mass per unit length (3.30×10^{-4} kg m^{-1}) to find the radius of the wire used.

Radius = ___________ m [2]

Examiner Only	
Marks	Remark

(b) Waves may be classified as *transverse* or *longitudinal* and *standing* or *progressive*.

Which type of wave is the vibration of the wire?

_______________________ and _______________________

It is possible to hear a note produced by the vibrating wire. Name the type of wave the vibration of the wire produces in the air.

_______________________ and _______________________ [2]

THIS IS THE END OF THE QUESTION PAPER

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GCE Physics

Data and Formulae Sheet for A2 1 and A2 2

Values of constants

speed of light in a vacuum	$c = 3.00 \times 10^{8}$ m s^{-1}
permittivity of a vacuum	$\varepsilon_0 = 8.85 \times 10^{-12}$ F m^{-1}
	$\left(\frac{1}{4\pi\varepsilon_0} = 8.99 \times 10^{9}\ \text{F}^{-1}\ \text{m}\right)$
elementary charge	$e = 1.60 \times 10^{-19}$ C
the Planck constant	$h = 6.63 \times 10^{-34}$ J s
(unified) atomic mass unit	1 u $= 1.66 \times 10^{-27}$ kg
mass of electron	$m_e = 9.11 \times 10^{-31}$ kg
mass of proton	$m_p = 1.67 \times 10^{-27}$ kg
molar gas constant	$R = 8.31$ J K^{-1} mol^{-1}
the Avogadro constant	$N_A = 6.02 \times 10^{23}$ mol^{-1}
the Boltzmann constant	$k = 1.38 \times 10^{-23}$ J K^{-1}
gravitational constant	$G = 6.67 \times 10^{-11}$ N m^{2} kg^{-2}
acceleration of free fall on the Earth's surface	$g = 9.81$ m s^{-2}
electron volt	1 e$V = 1.60 \times 10^{-19}$ J

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The following equations may be useful in answering some of the questions in the examination:

Mechanics

Conservation of energy	$\frac{1}{2}mv^2 - \frac{1}{2}mu^2 = Fs$	for a constant force
Hooke's Law	$F = kx$ (spring constant k)	

Simple harmonic motion

Displacement	$x = A\cos\omega t$

Sound

Sound intensity level/dB	$= 10\lg_{10}\frac{I}{I_0}$

Waves

Two-source interference	$\lambda = \frac{ay}{d}$

Thermal physics

Average kinetic energy of a molecule	$\frac{1}{2}m\langle c^2\rangle = \frac{3}{2}kT$
Kinetic theory	$pV = \frac{1}{3}Nm\langle c^2\rangle$
Thermal energy	$Q = mc\Delta\theta$

Capacitors

Capacitors in series	$\frac{1}{C} = \frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3}$
Capacitors in parallel	$C = C_1 + C_2 + C_3$
Time constant	$\tau = RC$

Light

Lens formula	$\frac{1}{u} + \frac{1}{v} = \frac{1}{f}$
Magnification	$m = \frac{v}{u}$

Electricity

Terminal potential difference	$V = E - Ir$ (E.m.f. E; Internal Resistance r)
Potential divider	$V_{\text{out}} = \frac{R_1 V_{\text{in}}}{R_1 + R_2}$

Particles and photons

Radioactive decay	$A = \lambda N$
	$A = A_0 e^{-\lambda t}$
Half-life	$t_{\frac{1}{2}} = \frac{0.693}{\lambda}$
de Broglie equation	$\lambda = \frac{h}{p}$

The nucleus

Nuclear radius	$r = r_0 A^{\frac{1}{3}}$