SERANGOON JUNIOR COLLEGE
JC2 PRELIMINARY EXAMINATION
General Certificate of Education Advanced Level
Higher 2

CANDIDATE NAME	
CIVICS GROUP	
INDEX NUMBER	

1234567S

PHYSICS 9646/02

Paper 2 Structured Questions

18 August 2011

1 hour 45 minutes

Candidates answer on the Question Paper.
No Additional Materials are required.

READ THESE INSTRUCTIONS FIRST

Write your name, Civics Group and index number on all the work you hand in.
Write in dark blue or black pen on both sides of the paper.
You may use a soft pencil for any diagrams, graphs or rough working.
Do not use staples, paper clips, highlighters, glue or correction fluid.

Answer **all** questions.

At the end of the examination, fasten all your work securely together.

The number of marks is given in bracket [ ] at the end of each question or part question.

For Examiner's Use	
1	
2	
3	
4	
5	
6	
7	
8	
9	
10	
Total	

This document consists of **18** printed pages and **no** blank page.

SERANGOON JUNIOR COLLEGE
Science Department Physics Unit

DATA AND FORMULAE

Data

speed of light in free space,	c	=	3.00×10^{8} m s^{-1}
permeability of free space,	μ_0	=	$4\pi \times 10^{-7}$ H m^{-1}
permittivity of free space,	ε_0	=	8.85×10^{-12} F m^{-1}
			$(1 / (36\pi)) \times 10^{-9}$ F m^{-1}
elementary charge,	e	=	1.60×10^{-19} C
the Planck constant,	h	=	6.63×10^{-34} J s
unified atomic mass constant,	u	=	1.66×10^{-27} kg
rest mass of electron,	m_e	=	9.11×10^{-31} kg
rest mass of proton,	m_p	=	1.67×10^{-27} kg
molar gas constant,	R	=	8.31 J K^{-1} mol^{-1}
the Avogadro constant,	N_A	=	6.02×10^{23} mol^{-1}
the Boltzmann constant,	k	=	1.38×10^{-23} J K^{-1}
gravitational constant,	G	=	6.67×10^{-11} N m^{2} kg^{-2}
acceleration of free fall,	g	=	9.81 m s^{-2}

Formulae

uniformly accelerated motion,	s	=	$ut + \frac{1}{2}at^2$
	v^2	=	$u^2 + 2as$
work done on/by a gas,	W	=	$p\Delta V$
hydrostatic pressure,	p	=	ρgh
gravitational potential,	ϕ	=	$-\dfrac{Gm}{r}$
displacement of particle in s.h.m.,	x	=	$x_0 \sin \omega t$
velocity of particle in s.h.m.,	v	=	$v_o \cos\omega t$
	v	=	$\pm\,\omega\sqrt{\left(x_0^2 - x^2\right)}$
resistors in series,	R	=	$R_1 + R_2 + \ldots$
resistors in parallel,	$1/R$	=	$1/R_1 + 1/R_2 + \ldots$
electric potential,	V	=	$Q / 4\pi\varepsilon_o r$
alternating current/voltage,	x	=	$x_0 \sin\omega t$
transmission coefficient,	T	$\propto$	$\exp(-2kd)$
			where $k = \sqrt{\dfrac{8\pi^2 m(U-E)}{h^2}}$
radioactive decay,	x	=	$x_0 \exp(-\lambda t)$
decay constant,	λ	=	$\dfrac{0.693}{t_{\frac{1}{2}}}$

Answer all questions

1 A SRJC student who intends to major in Physics in university attempted to recall Bernoulli's equation, widely used in the field of fluid dynamics. Based on his recollection during H3 lectures, he was able to come up with the following equation:

$$k = p + h\rho g + \frac{1}{2}\rho v^{a}$$

where p is pressure, h is height, ρ is density, v is velocity and k is a constant. However, he was unable to recall the value of a.

(a) Based on dimensional analysis (i.e. comparison of units of terms in the equation), determine the value of a.

a = ... [2]

(b) Under certain conditions, the equation reduces to $k = \frac{1}{2}\rho v^{a}$. Calculate the percentage uncertainty in k, given the values of the quantities as listed below.

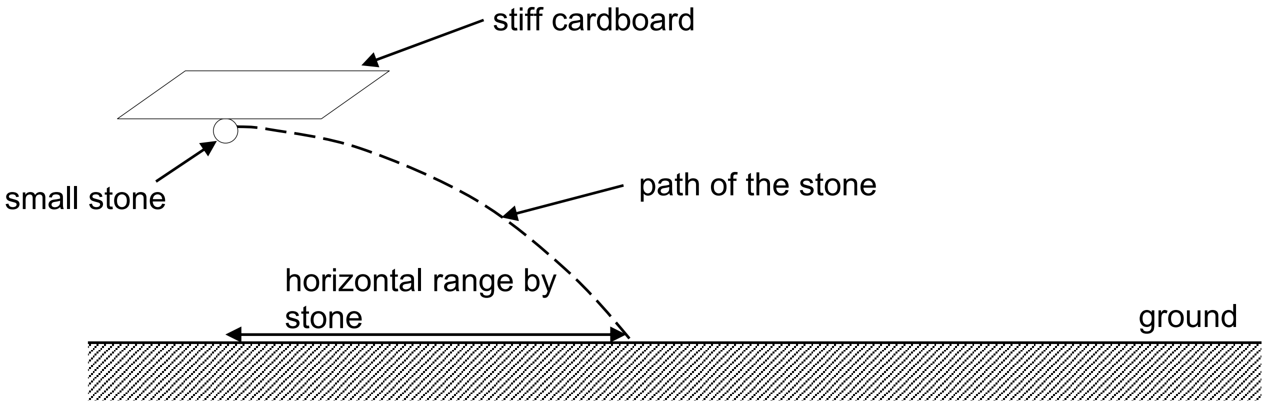
ρ = (1000 ± 2%) kg m^{-3}
v = (20.0 ± 0.2) m s^{-1}

percentage uncertainty = ... % [2]

2 **(a)** Derive, from the definitions of velocity and acceleration, the expression

$$v^2 = u^2 + 2as.$$ [2]

(b) In an experiment to test the effect of air resistance on different objects, a small stone and a thin piece of stiff cardboard are separately projected horizontally from the same vertical height, at the same initial speed. The figure below shows the path taken by the stone.



The plane of the cardboard remains parallel to the ground during its journey.

(i) Explain why the horizontal range covered by the path of the cardboard is observed to be further than that of the stone.

……………………………………………………………………………………………..

……………………………………………………………………………………………..

……………………………………………………………………………………………..

……………………………………………………………………………………………..

……………………………………………………………………………………………..

…………………………………………………………………………………………….[2]

For Examiner's Use

(ii) Describe and explain if the final velocity of the cardboard before hitting the ground is higher, lower or the same, than that for the stone.

…………………………………………………………………………………………...

…………………………………………………………………………………………...

…………………………………………………………………………………………...

…………………………………………………………………………………………...

…………………………………………………………………………………………...

……………………………………………………………………………………….[2]

For Examiner's Use

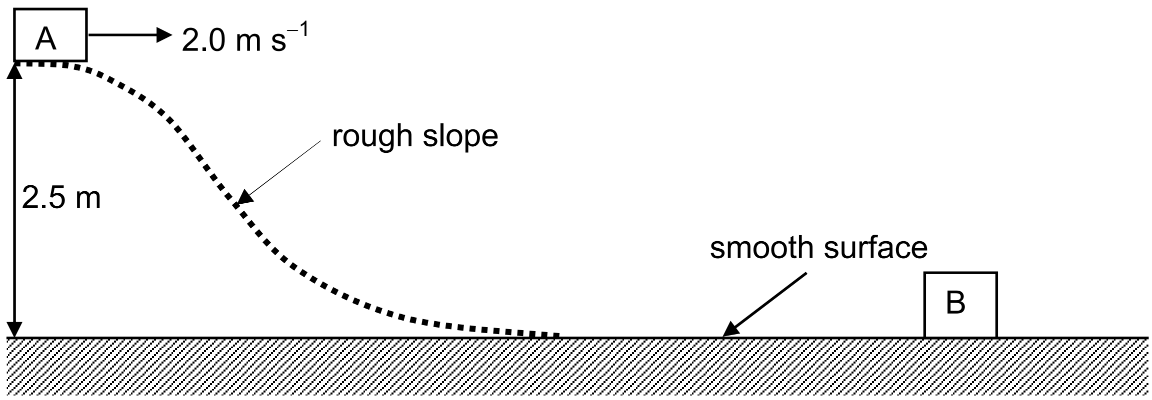
3 **(a)** State the *Principle of Conservation of Linear Momentum*.

....

....

....[1]

(b) Box A, of mass 1.5 kg, slides down a rough slope with an initial velocity of 2.0 m s^{-1}. The vertical height of the slope is 2.5 m and the work done against friction by Box A is 5.0 J.



(i) Calculate the velocity of Box A at the bottom of the slope.

velocity of Box A at bottom of slope = ………………… m s^{-1} [2]

(ii) At the bottom of the slope, Box A travels along a smooth surface before colliding elastically with a stationary Box B of mass 3.0 kg.

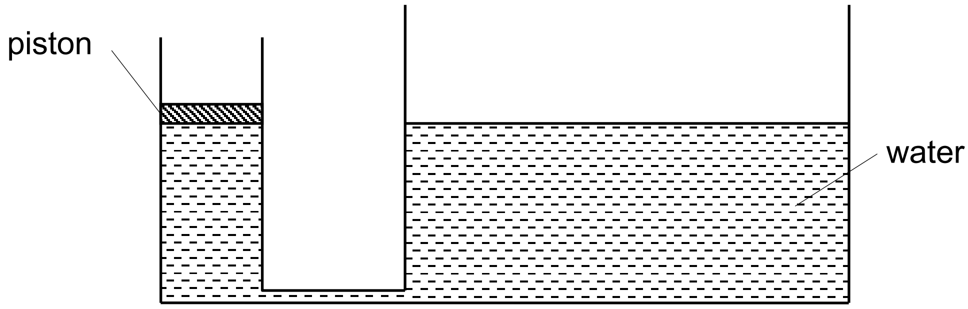
Calculate the final speeds of Box A and Box B.

speed of Box A = …………………….. m s^{-1}

speed of Box B = ..……………………. m s^{-1} [3]

For Examiner's Use

4 A tank with an L-shaped pipe is to be used as a weighing scale. A light airtight frictionless piston is in the pipe, and is in contact with the water. The cross-sectional area of the tank is 4 times that of the piston. The connecting pipe has negligible volume.



Initially, the water levels in the pipe and tank are equal. An object is placed gently on the piston and the piston descends to a new height. It is observed that the piston descends by 2.0 cm.

(a) **(i)** Calculate the difference in water levels within the pipe and tank.

difference in water levels = …………………… cm [2]

(ii) Hence calculate the mass of the object. The cross-sectional area of the piston is 0.01 m^2, and the density of water is 1000 kg m^{-3}.

mass of object = …………………. kg [2]

(b) "Friction always causes energy to be dissipated." With reference to a suitable example, suggest why this statement is not true.

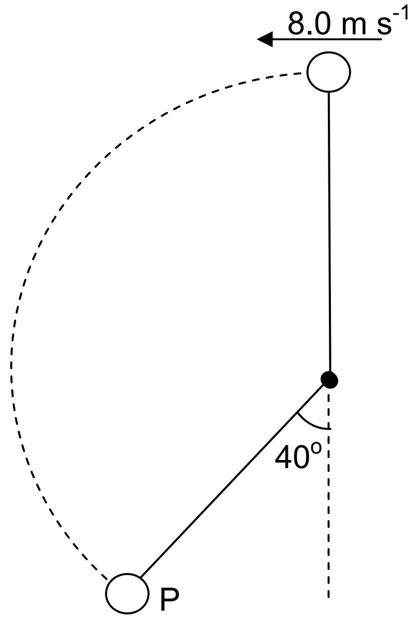
....

……………………………………………………………………………………………...

……………………………………………………………………………………………[2]

For Examiner's Use

5 A pendulum bob of mass 5.0 kg is projected at a speed of 8.0 m s^{-1} at the top of a vertical circle as shown in the diagram below. The radius of the circular path is 1.50 m.



(a) Calculate the speed of the bob when it reaches point P.

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

(b) Determine the tension at point P.

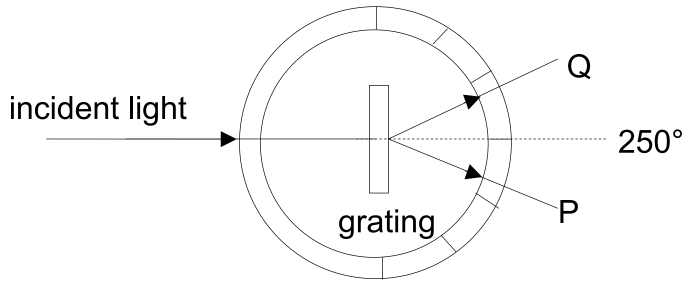
tension = ... N [2]

(c) State and explain where the string is most likely to break.

....

.... [2]

6 A narrow beam of coherent light of wavelength 589 nm falls normally on a diffraction grating having 500 lines per millimetre. The diffraction grating is situated at the centre of a circular scale.



The straight through direction is at the reading of 250° on the scale. A detector is placed at P, where the reading on the scale is 210°. The detector is then moved towards Q, where the reading on the scale is 290°.

(a) Determine the number of spectral lines detected as the detector moves from P to Q.

number of spectral lines detected = ………………….. [2]

(b) Explain how the angular separation between two spectral lines of the same order can be increased.

....

……………………………………………………………………………………………...

……………………………………………………………………………………………[2]

(c) State and explain the problem that is likely to arise when observing the spectral lines at a higher order.

....

……………………………………………………………………………………………...

....

……………………………………………………………………………………………[2]

For Examiner's Use

7 **(a)** Explain, with the aid of a diagram, what is meant by a *potential barrier*.

....

....

....

....[2]

(b) Using classical mechanics, explain why it is impossible for the particle to penetrate a potential barrier.

....

....

....

....

....

....[1]

(c) Discuss how the wave nature of particles allows particles to tunnel through such a barrier.

....

....

....

....

....

....[2]

For Examiner's Use

8 A radioactive sample contains an isotope of Iodine-124. A Geiger-Muller tube is placed at a distance from the source to obtain a count rate.

(a) **(i)** Explain what is meant by the term *isotope*.

…………………………………………………………………………………………

…………………………………………………………………………………………[1]

(ii) The activity of the radioactive sample is much higher than the count rate (per second) registered by the Geiger Muller tube. Suggest a reason for this.

…………………………………………………………………………………………

…………………………………………………………………………………………[1]

(b) **(i)** The sample has a mass of 50 g. Iodine accounts for 0.3% of the sample mass and only 0.116% of this belongs to the Iodine-124 isotope.

Calculate

1. the number of moles of Iodine-124 present in the sample,

number of moles of Iodine-124 = ……………………. [2]

2. the number of Iodine-124 atoms present in the sample.

number of Iodine-124 atoms = ……………………. [2]

For Examiner's Use

(ii) The background radiation count rate was found to be 5.0% of the initial total count rate.

After a period of time, the count rate fell to 70.0% of the initial count rate. Assuming that the background radiation remains constant, calculate the number of Iodine-124 nuclides remaining in the sample.

number of nuclides remaining = ……………………. [2]

(iii) The half-life of Iodine-124 is 4.2 days. Calculate the time taken, in days, for the fall in count rate mentioned in **(b)(ii)**.

time taken = ……………………. days [2]

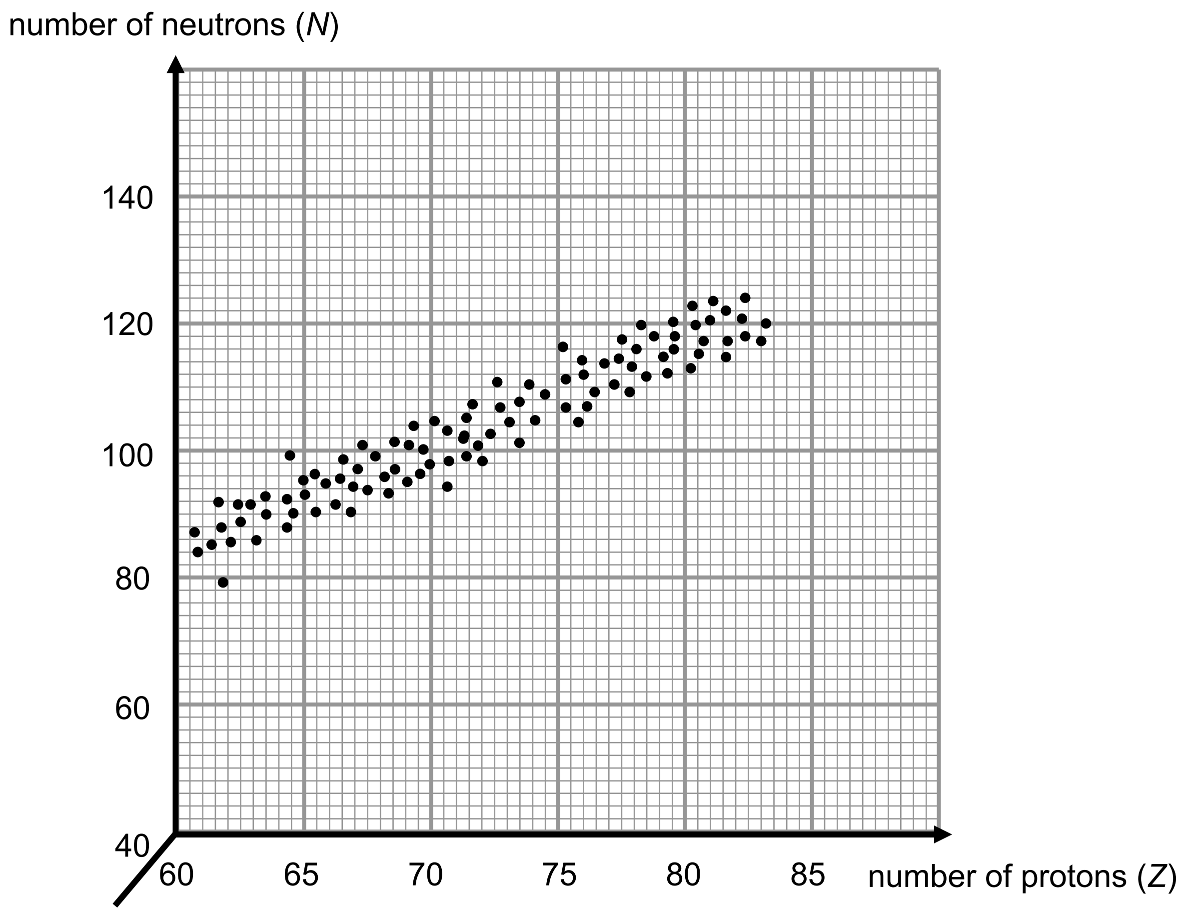
9 One particular model of an atom which was developed in the early 1900s suggested that the core of an atom consists of a massive nucleus. The nucleus is made up of nucleons – the protons (charge of +1.6 × 10^{-19} C) and neutrons (chargeless) – giving its net positive charge. Charged particles interact via the long-range Coulomb force. In the case of like charges such as protons, the electrostatic force between them is repulsive and varies inversely with the square of the distance between them,

$$F = k\frac{Q_1 Q_2}{r^2}$$

where	Q_1 and Q_2	= magnitude of charges	[C]
	k	= 8.99 × 10^9	[F^{-1} m]
	r	= distance between the charges	[m]

All the nucleons also undergo another force known as the nuclear force. This is an attractive force which is strong enough to overcome the Coulomb force between protons in the short range, i.e. comparable to the spacing between nucleons in a nucleus.

As a result of the forces which the nucleons undergo within each nucleus, nuclei have different extents of stability. Each plot on the graph below represents one nucleus.



(a) The electrostatic force between like charges is a repulsive force.

State one other type of repulsive force.

……………………………………………………………………………………………...

……………………………………………………………………………………..……..[1]

(b) Small nuclei which have less than 40 nucleons have approximately equal numbers of neutrons (*N*) and protons (*Z*). For large nuclei, the values of *N* and *Z* vary according to the equation:

$$N = mZ$$

where *m* is a constant.

(i) Sketch the graph of $N = Z$ in the graph above. [1]

(ii) Determine an approximate value for *m*. Show your working clearly.

m = ………………………… [2]

(c) Using the information provided, explain why the existence of the long-range Coulomb force and the short-range nuclear force causes instability in large nuclei if the number of neutrons (*N*) is equal to the number of protons (*Z*).

……………………………………………………………………………………………..

……………………………………………………………………………………………..

……………………………………………………………………………………………..

……………………………………………………………………………………………..

……………………………………………………………………………………………..

……………………………………………………………………………………………..

……………………………………………………………………………………………..

……………………………………………………………………………………..…….[2]

(d) Consider 2 protons which are positioned at the furthest possible distance apart in a large spherical nucleus of radius 7.5×10^{-15} m. Calculate the electrostatic force of repulsion experienced by one charge due to the other.

F = ………………………….N [2]

(e) Suggest, with explanation, if this value of electrostatic force is higher or lower than the actual force experienced by the same charge.

……………………………………………………………………………………………..

……………………………………………………………………………………………..

……………………………………………………………………………………………..

……………………………………………………………………………………..…….[2]

(f) For large nuclei which are unstable, suggest one way they can become more stable.

…………………………………………………………………………………………….

……………………………………………………………………………………..…….[1]

For Examiner's Use

10 Noise reduces productivity and is a common problem in cities. In general, other than loudness, noise can be characterized by pitch – for example, road noise and the noise produced by heavy rain is considered low-pitched while sirens are high-pitched noises. Some noises consist of sounds of different pitch, such as noise produced from military aircraft flying overhead.

Researchers have developed a new kind of lightweight curtain that can absorb sound waves while still letting light through. The material absorbs a portion of the sound energy that strikes it, and only a portion is transmitted. The curtains have been proposed as a method of reducing the amount of noise entering a room through open windows.

Design an experiment to determine how the effectiveness of the curtain depends on the nature of the sound.

You should draw labelled diagrams to show the arrangement of your apparatus.

In your account you should pay particular attention to

(a) how you would determine the effectiveness of the curtain,

(b) the equipment you would use for the investigation,

(c) the procedure to be followed,

(d) the control of variables,

(e) any safety precautions,

(f) any precautions that you would take to improve the accuracy of the experiment.

[12]

Diagram

For Examiner's Use

END OF PAPER