Cambridge Pre-U

UNIVERSITY OF CAMBRIDGE INTERNATIONAL EXAMINATIONS
Cambridge International Level 3 Pre-U Certificate
Principal Subject

CANDIDATE NAME

CENTRE NUMBER | CANDIDATE NUMBER

0113590453

PHYSICS **9792/02**

Paper 2 Part A Written Paper **May/June 2012**

2 hours

Candidates answer on the Question Paper.

No Additional Materials are required.

READ THESE INSTRUCTIONS FIRST

Write your Centre number, candidate number and name on all the work you hand in.
Write in dark blue or black pen.
You may use a pencil for any diagrams, graphs or rough working.
Do not use staples, paper clips, highlighters, glue or correction fluid.
DO **NOT** WRITE IN ANY BARCODES.

Section A
Answer **all** questions.
You are advised to spend about 1 hour 30 minutes on this section.

Section B
Answer the **one** question.
You are advised to spend about 30 minutes on this section.
The question is based on the material in the Insert.

You may lose marks if you do not show your working or if you do not use appropriate units.

At the end of the examination, fasten all your work securely together.
The number of marks is given in brackets [ ] at the end of each question or part question.

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

This document consists of **20** printed pages, **4** blank pages and **1** insert.

DC (LEO/JG) 51110/4

UNIVERSITY of CAMBRIDGE International Examinations

[Turn over

Data

gravitational field strength close to Earth's surface	$g = 9.81\,\mathrm{N\,kg^{-1}}$
elementary charge	$e = 1.60 \times 10^{-19}\,\mathrm{C}$
speed of light in vacuum	$c = 3.00 \times 10^{8}\,\mathrm{m\,s^{-1}}$
Planck constant	$h = 6.63 \times 10^{-34}\,\mathrm{J\,s}$
permittivity of free space	$\varepsilon_0 = 8.85 \times 10^{-12}\,\mathrm{F\,m^{-1}}$
gravitational constant	$G = 6.67 \times 10^{-11}\,\mathrm{N\,m^{2}\,kg^{-2}}$
electron mass	$m_e = 9.11 \times 10^{-31}\,\mathrm{kg}$
proton mass	$m_p = 1.67 \times 10^{-27}\,\mathrm{kg}$
unified atomic mass constant	$u = 1.66 \times 10^{-27}\,\mathrm{kg}$
molar gas constant	$R = 8.31\,\mathrm{J\,K^{-1}\,mol^{-1}}$
Avogadro constant	$N_A = 6.02 \times 10^{23}\,\mathrm{mol^{-1}}$
Boltzmann constant	$k = 1.38 \times 10^{-23}\,\mathrm{J\,K^{-1}}$
Stefan-Boltzmann constant	$\sigma = 5.67 \times 10^{-8}\,\mathrm{W\,m^{-2}\,K^{-4}}$

Formulae

uniformly accelerated motion	$s = ut + \frac{1}{2}at^2$
	$v^2 = u^2 + 2as$
	$s = \left(\frac{u+v}{2}\right)t$
heating	$\Delta E = mc\Delta\theta$
change of state	$\Delta E = mL$
refraction	$n = \frac{\sin\theta_1}{\sin\theta_2}$
	$n = \frac{v_1}{v_2}$
photon energy	$E = hf$
de Broglie wavelength	$\lambda = \frac{h}{p}$
simple harmonic motion	$x = A\cos\omega t$
	$v = -A\omega\sin\omega t$
	$a = -A\omega^2\cos\omega t$
	$F = -m\omega^2 x$
	$E = \frac{1}{2}mA^2\omega^2$
energy stored in a capacitor	$W = \frac{1}{2}QV$
electric force	$F = \frac{Q_1Q_2}{4\pi\varepsilon_0 r^2}$
electrostatic potential energy	$W = \frac{Q_1Q_2}{4\pi\varepsilon_0 r}$
gravitational force	$F = \frac{-Gm_1m_2}{r^2}$
gravitational potential energy	$E = \frac{-Gm_1m_2}{r}$

magnetic force	$F = BIl\sin\theta$
	$F = BQv\sin\theta$
electromagnetic induction	$E = \frac{-\mathrm{d}(N\Phi)}{\mathrm{d}t}$
Hall effect	$V = Bvd$
time dilation	$t' = \frac{t}{\sqrt{1-\frac{v^2}{c^2}}}$
kinetic theory	$\frac{1}{2}m\langle c^2\rangle = \frac{3}{2}kT$
work done on/by a gas	$W = p\Delta V$
radioactive decay	$\frac{\mathrm{d}N}{\mathrm{d}t} = -\lambda N$
	$N = N_0 e^{-\lambda t}$
	$t_{\frac{1}{2}} = \frac{\ln 2}{\lambda}$
attenuation losses	$I = I_0 e^{-\mu x}$
mass-energy equivalence	$\Delta E = c^2\Delta m$
hydrogen energy levels	$E_n = \frac{-13.6\,\text{eV}}{n^2}$
Heisenberg uncertainty principle	$\Delta p\,\Delta x \geqslant \frac{h}{2\pi}$
	$\Delta E\,\Delta t \geqslant \frac{h}{2\pi}$
Wien's law	$\lambda_{max} \propto \frac{1}{T}$
Stefan's law	$L = 4\pi\sigma r^2 T^4$
electromagnetic radiation from a moving source	$\frac{\Delta\lambda}{\lambda} \approx \frac{\Delta f}{f} \approx \frac{v}{c}$

Section A

For Examiner's Use

You are advised to spend 1½ hours answering this section.

1 **(a)** **(i)** State the difference between a vector and a scalar quantity.

....

....

....[1]

(ii) Give two examples of each.

scalar	vector
1.	1. ....
2.	2. ....

[2]

(b) **(i)** Fig. 1.1 represents three vectors A, B and C.

Draw a sketch diagram in the space to the right of Fig. 1.1, to represent a vector D as the sum of the three vectors A, B and C.

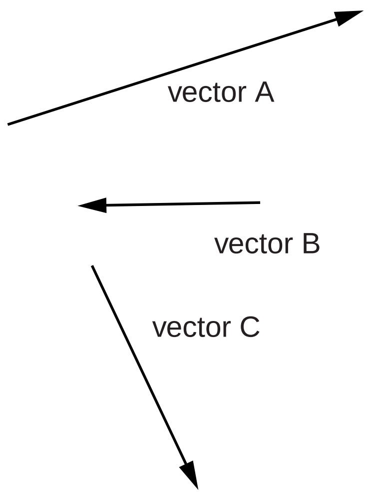

Fig. 1.1

[2]

(ii) Fig. 1.2 represents a vector E of magnitude 37 units.

For Examiner's Use

Calculate the magnitudes of the components of vector E in the *x*-direction and in the *y*-direction.

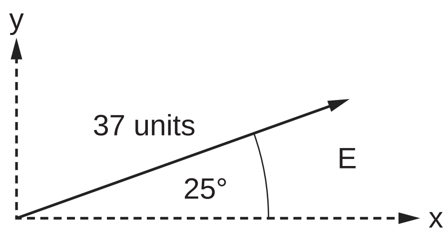

Fig. 1.2 (not to scale)

component in *x*-direction = ... units

component in *y*-direction = ... units [2]

[Total: 7]

For Examiner's Use

2 **(a)** Newton's third law of motion can be expressed in the following form.

When body A exerts a force on body B then body B exerts a force on body A. These forces are

- equal in magnitude,
- opposite in direction,
- of the same type.

Explain, using labelled force diagrams, how this applies to

(i) an object in free fall (no air resistance),

....

.... [2]

(ii) an object at rest on the floor.

....

.... [2]

For Examiner's Use

(b) Air resistance increases as the speed of a falling object increases.

(i) On Fig. 2.1, sketch a graph to show how the speed of an object falling from rest in air varies with time.

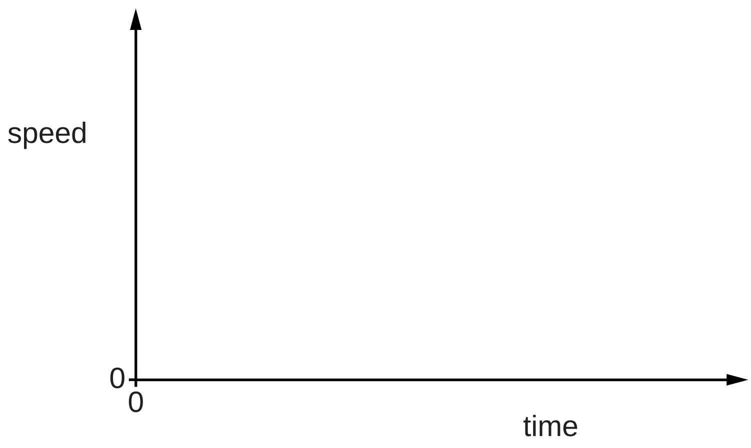

Fig. 2.1

[2]

(ii) Explain how Newton's third law applies as the air resistance on the falling object increases.

....

....

....

....

....[2]

[Total: 8]

For Examiner's Use

3 **(a)** From the definition of work done, show that power = force × velocity.

....

....

....

....[2]

(b) A car of mass 850 kg travelling at a constant speed of 12.0 $m\,s^{-1}$ has a power output of 1800 W.

Determine,

(i) the driving force,

driving force = ... N [1]

(ii) the total resistive force on the car.

resistive force = ... N [1]

(c) The car in **(b)** accelerates from 12.0 $m\,s^{-1}$ with an initial acceleration of 2.50 $m\,s^{-2}$.

Calculate the new driving force.

driving force = ... N [2]

For Examiner's Use

(d) After accelerating, the car in **(c)** reaches a constant speed of 36.0 m s^{-1}. The resistive force on the car is proportional to its speed squared.

Calculate

(i) the new resistive force on the car at 36.0 m s^{-1},

resistive force = ... N [2]

(ii) the new power output.

power output = ... W [1]

(e) When travelling at constant speed, the mathematical relationship between power output P and speed v is

$$P \propto v^n.$$

The power output at 12.0 m s^{-1} is 1800 W.

Using your answer to **(d)(ii)**, show that n = 3.

[2]

[Total: 11]

For Examiner's Use

4 Fig. 4.1 is a diagram of a domestic electrical circuit. The circuit allows many electrical components to be individually switched on or off. The supply voltage is 240 V.

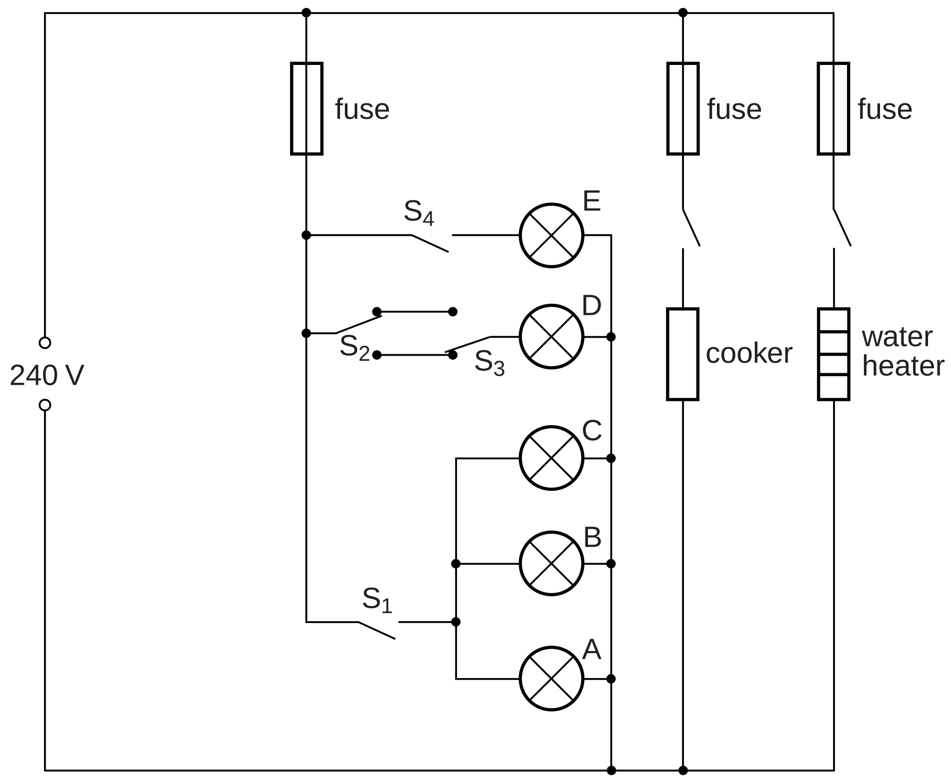

Fig. 4.1

(a) **(i)** The water heater has a resistance of 20 Ω. Calculate the power of the water heater.

power = ... W [3]

(ii) Calculate the time it will take the water heater to raise the temperature of 33 kg of water from 20 °C to 60 °C, assuming no heat loss. The specific heat capacity of water is 4200 J kg^{-1} °C^{-1}.

time = ... s [2]

(b) **(i)** State the effect of closing switch S_1.

.... [1]

(ii) Explain how switches S_2 and S_3 control lamp D.

....

....

.... [2]

(iii) Calculate the resistance of lamp E, which is rated 10W.

resistance = ... Ω [2]

(c) All the electrical sockets in a house are connected to a circuit called a ring main. The circuit is connected between P and Q to the 240V supply as shown in Fig. 4.2.

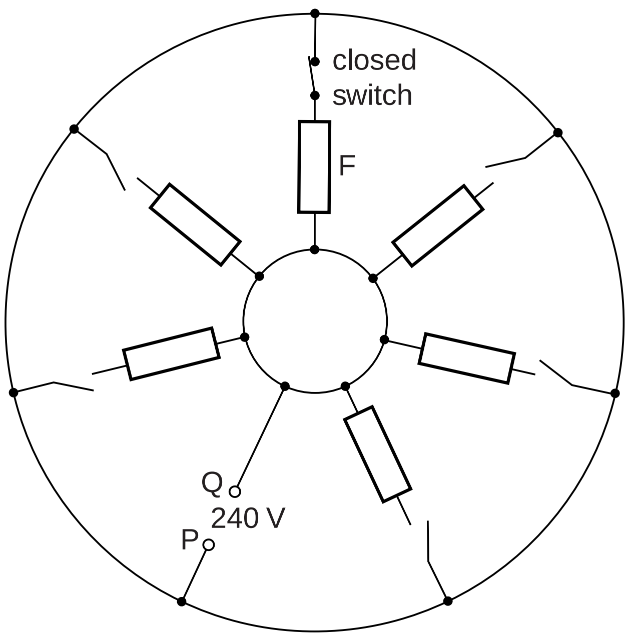

Fig. 4.2

(i) All the switches are open except the one to a computer at F, which is closed as shown. Draw arrows on Fig. 4.2 to show the paths of the current when the computer is in use at an instant in time when P is positive. [2]

(ii) Suggest two advantages of using a ring main.

1. ....

....

2. ....

.... [2]

[Total: 14]

For Examiner's Use

5 **(a)** Describe the basic difference between the following terms. You may use diagrams to illustrate your answers.

(i) a *transverse* wave and a *longitudinal* wave

....

....[2]

(ii) a *polarised* and a *non-polarised* wave

....

....[2]

(iii) a *standing* wave and a *progressive* wave

....

....[3]

For Examiner's Use

(b) (i) The light from a sodium lamp is analysed using an instrument containing a diffraction grating. The diffraction grating has 500 lines per millimetre. A spectral line in the second order spectrum is at an angle of 36.09°.

Use the equation $n\lambda = d\sin\theta$ to calculate the wavelength of the light causing this spectral line.

wavelength = ... m [3]

(ii) There is another second order spectral line at 36.13°.

Calculate the wavelength of the light causing this line.

wavelength = ... m [1]

(iii) The spectral lines are viewed using a lens of aperture *b*.

Use the Rayleigh criterion, $\theta \approx \lambda/b$, to find the approximate minimum size of the aperture that is able to resolve the two spectral lines.

minimum size = ... m [3]

[Total: 14]

For Examiner's Use

6 **(a)** In a fission process a neutron collides with a uranium-235 nucleus and causes a nuclear reaction summarised by the following equation.

$$^{1}_{0}n + ^{235}_{92}U \rightarrow ^{P}_{Q}X \rightarrow ^{R}_{54}Xe + ^{90}_{38}Sr + 3^{1}_{0}n + \text{energy}$$

(i) Give the numerical values of P, Q and R.

P = ...

Q = ...

R = ...
[2]

(ii) State the feature of this equation that indicates that a chain reaction may be possible.

....

....

....

....[1]

(b) A strontium-90 nucleus emits a β^- particle and decays to yttrium (Y). The decay has a half-life of 28 years.

(i) Write a nuclear transformation equation for the emission of the β^- particle.

[2]

(ii) In a laboratory source of strontium-90, the number of atoms present in the year 2012 is 2.36×10^{13}.

Calculate the number of strontium atoms that will be present in the source in the year 2124 (112 years later).

number = ...[3]

[Total: 8]

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Section A continues on the next page.

For Examiner's Use

7 **(a)** The equation $hf = \Phi + ½mv^2_{max}$ is used in the theory of the photoelectric effect.

Describe the photoelectric effect and explain what the three terms in the equation represent.

....

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....[6]

(b) Describe an experiment used to determine v_{max} in the equation in **(a)**. You may include a diagram showing the arrangement and electrical circuit.

....

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....

....

....

....

....[4]

(c) The photoelectric effect was important in the development of a photon theory of electromagnetic radiation.

For Examiner's Use

(i) State one observation of the photoelectric effect that cannot be explained using the wave model.

....

....

.... [1]

(ii) Explain how the wave model fails to account for this observation.

....

....

.... [1]

(iii) Explain how the photon model can account for this observation.

....

....

.... [1]

[Total: 13]

Section B

You are advised to spend about 30 minutes answering this section.
Your answers should, where possible, make use of any relevant Physics.

8 The maglev train referred to in Extract 2 consists of 5 sections, each of mass 4.80×10^4 kg. The train leaves a station and accelerates uniformly for 150 s. Fig. 8.1 is the velocity / time graph for the first 400 s of the journey.

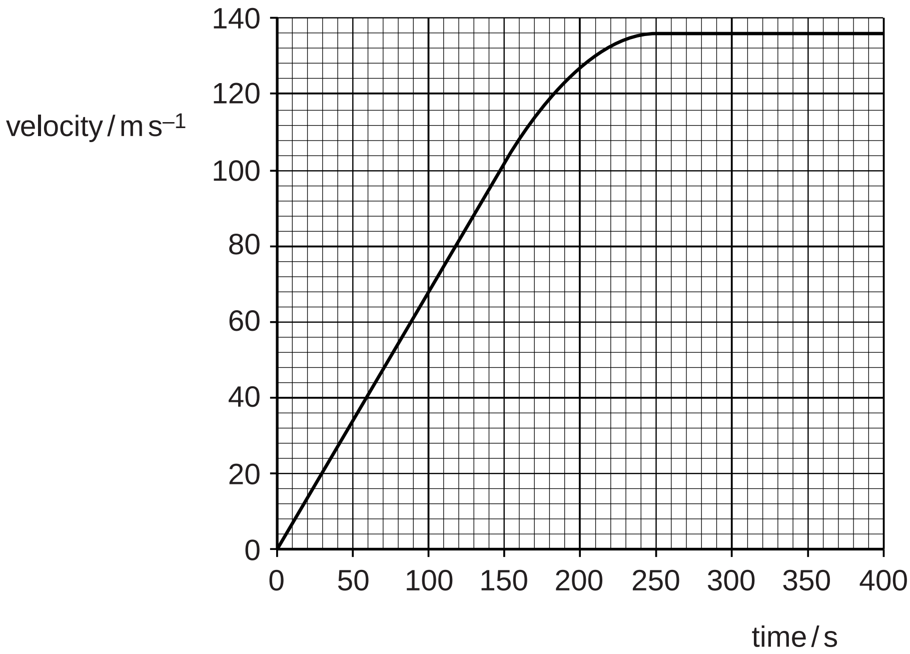

Fig. 8.1

(a) **(i)** Use Fig. 8.1 to determine the acceleration of the train between t = 0 and t = 150 s.

acceleration = ... m s^{-2} [2]

(ii) Calculate the resultant force acting on the train during the first 150 s of the journey.

force = ... N [2]

(iii) Hence state the rate at which the momentum of the train is changing during this time.

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

For Examiner's Use

(b) For the first 400 s of its journey, the train is travelling along a straight, horizontal track. The train is powered by linear induction motors such as those referred to in Extract 4. During the first 150 s of the journey, the force exerted on the train by the motors increases continuously.

Suggest why, despite the increasing force exerted by the motors, the acceleration of the train remains constant.

....

....

....[2]

(c) The train reaches its maximum velocity at 250 s. Use Fig. 8.1 to estimate the distance travelled by the train as it accelerates.

distance = ... m [2]

(d) At 400 s, the train reaches a section of track that has an upward gradient of 2.00% (0.0200). A gradient of 2.00% means that the train gains 2.00 m in height for every 100 m it moves along the track. Along this upward section of the track, the train continues to travel at the same constant speed.

(i) Use Fig. 8.1 to determine the speed of the train on this upward section of the track.

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

(ii) Calculate the gain in gravitational potential energy of the train in 1.0 s.

energy gained in 1.0 s = ... J [3]

(iii) At 300 s, the power supplied to the train is 9.80×10^7 W.

For Examiner's Use

Calculate the percentage increase in the power supplied to the train as it starts to travel uphill.

increase = ...% [2]

(e) The electromagnets used to levitate the train above the guideway have coils made from a material that is a superconductor.

(i) State what is meant by a *superconductor*.

....

....[1]

(ii) State one advantage and one disadvantage of using a superconductor for this purpose.

advantage ....

....[1]

disadvantage ....

....[1]

For Examiner's Use

(f) In many parts of the world, high-speed railway systems have been built between big cities. A very large majority of these are conventional wheel-on-rail systems.

Explain the advantages and disadvantages of linking big cities with maglev systems rather than conventional railways and suggest why so few maglev railways have been built. You may use information from any of the extracts.

Your answer should concentrate on the social, environmental and economic effects of such a project.

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....[7]

[Total: 25]

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