IB DIPLOMA Topical Past Papers

# PHYSICS

## HL

## PAPER 2

2017 — 2023


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|---|---|---|
| Chapter 1 | **Measurements & Uncertainties** | Page 1 |
| Chapter 2 | **Mechanics** | Page 6 |
| Chapter 3 | **Thermal Physics** | Page 58 |
| Chapter 4 | **Oscillations & Waves** | Page 93 |
| Chapter 5 | **Electricity & Magnetism** | Page 155 |
| Chapter 6 | **Circular Motion & Gravitation** | Page 214 |
| Chapter 7 | **Atomic, Nuclear & Particle Physics** | Page 246 |
| Chapter 8 | **Energy Production** | Page 298 |
| Chapter 9 | **Wave Phenomena** | Page 319 |
| Chapter 10 | **Fields** | Page 361 |
| Chapter 11 | **Electromagnetic Induction** | Page 390 |
| Chapter 12 | **Quantum & Nuclear Physics** | Page 438 |
| | **ANSWERS** | Page 479 |

**1** - (PHYSI/21_HL_Summer_2017_Q7) - *Oscillations & Waves, Measurements & Uncertainties*

A student is investigating a method to measure the mass of a wooden block by timing the period of its oscillations on a spring.

(a) Describe the conditions required for an object to perform simple harmonic motion (SHM). [2]

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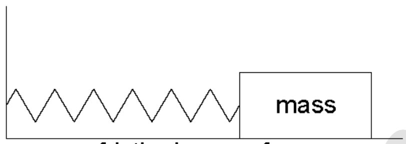
(b) A 0.52 kg mass performs simple harmonic motion with a period of 0.86 s when attached to the spring. A wooden block attached to the same spring oscillates with a period of 0.74 s.




Calculate the mass of the wooden block. [2]

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(c) In carrying out the experiment the student displaced the block horizontally by 4.8 cm from the equilibrium position. Determine the total energy in the oscillation of the wooden block. [3]

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(d) A second identical spring is placed in parallel and the experiment in (b) is repeated. Suggest how this change affects the fractional uncertainty in the mass of the block. [3]

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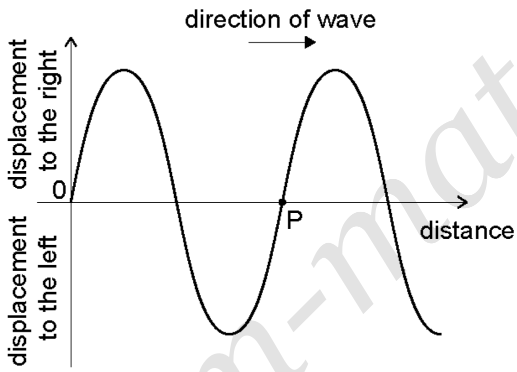
(e) With the block stationary a longitudinal wave is made to travel through the original spring from left to right. The diagram shows the variation with distance $x$ of the displacement $y$ of the coils of the spring at an instant of time.




A point on the graph has been labelled that represents a point P on the spring.

(i) State the direction of motion of P on the spring. [1]

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(ii) Explain whether P is at the centre of a compression or the centre of a rarefaction. [2]

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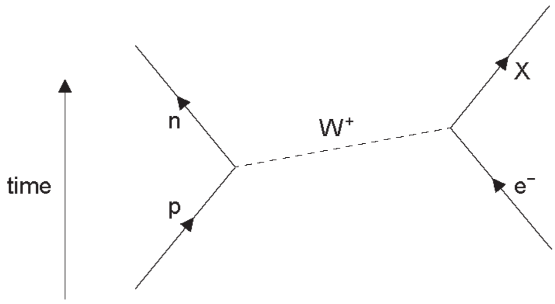
**2** - (PHYSI/20_HL_Winter_2017_Q3) - *Atomic,nuclear & Particle Physics, Quantum & Nuclear Physics (ahl), Measurements & Uncertainties*

(a) The Feynman diagram shows electron capture.




(i) State and explain the nature of the particle labelled X. [3]

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(ii) Distinguish between hadrons and leptons. [2]

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(b) Particles can be used in scattering experiments to estimate nuclear sizes.

(i) Outline how these experiments are carried out. [2]

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(ii) Outline why the particles must be accelerated to high energies in scattering experiments. [3]

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(c) State and explain **one** example of a scientific analogy. [2]

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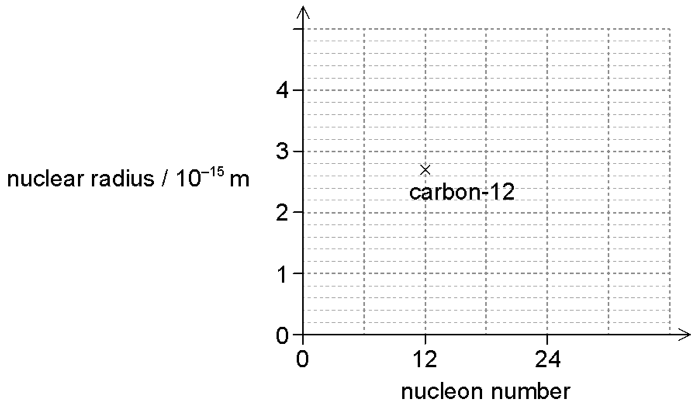
(d) Electron diffraction experiments indicate that the nuclear radius of carbon-12 $\left({}^{12}_{6}\text{C}\right)$ is $2.7 \times 10^{-15}$ m. The graph shows the variation of nuclear radius with nucleon number. The nuclear radius of the carbon-12 is shown on the graph.




(i) Determine the radius of the magnesium-24 $\left({}^{24}_{12}\text{Mg}\right)$ nucleus. [2]

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(ii) Plot the position of magnesium-24 on the graph. [1]

(iii) Draw a line on the graph, to show the variation of nuclear radius with nucleon number. [2]

# ANSWERS

**1** - (PHYSI/21_HL_Summer_2017_Q7) - *Oscillations & Waves, Measurements & Uncertainties*

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| a | | acceleration/restoring force is proportional to displacement ✓<br>and in the opposite direction/directed towards equilibrium ✓ |
| b | | ***ALTERNATIVE 1***<br>$\frac{T_1^2}{T_2^2}=\frac{m_1}{m_2}$ ✓<br>mass = 0.38 / 0.39 «kg» ✓<br>***ALTERNATIVE 2***<br>«use of $T=2\pi\sqrt{\frac{m}{k}}$» $k=28$ «$Nm^{-1}$» ✓<br>«use of $T=2\pi\sqrt{\frac{m}{k}}$» $m=0.38 / 0.39$ «kg» ✓ |
| c | | $\omega=$ «$\frac{2\pi}{0.74}$» $=8.5$ «$rads^{-1}$» ✓<br>total energy $=\frac{1}{2}\times0.39\times8.5^2\times\left(4.8\times10^{-2}\right)^2$ ✓<br>= 0.032 «J» ✓ |
| d | | spring constant/k/stiffness would increase ✓<br>*T* would be smaller ✓<br>fractional uncertainty in *T* would be greater, so fractional uncertainty of mass of block would be greater ✓ |

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| e | i | left ✓ |
| | ii | coils to the right of P move right and the coils to the left move left ✓<br>hence P at centre of rarefaction ✓ |

**2** - (PHYSI/20_HL_Winter_2017_Q3) - *Atomic,nuclear & Particle Physics, Quantum & Nuclear Physics (ahl), Measurements & Uncertainties*

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|---|---|---|---|
| **a** | **i** | «electron» neutrino ✓<br>it has a lepton number of 1 «as lepton number is conserved» ✓<br>it has a charge of zero/is neutral «as charge is conserved»<br>***OR***<br>it has a baryon number of 0 «as baryon number is conserved» ✓ | *Do not allow antineutrino*<br>*Do not credit answers referring to energy* |
| **a** | **ii** | hadrons experience strong force<br>***OR***<br>leptons do not experience the strong force ✓<br>hadrons made of quarks/not fundamental<br>***OR***<br>leptons are not made of quarks/are fundamental ✓<br>hadrons decay «eventually» into protons<br>***OR***<br>leptons do not decay into protons ✓ | *Accept leptons experience the weak force*<br>*Allow "interaction" for "force"* |
| **b** | **i** | «high energy particles incident on» thin sample ✓<br>detect angle/position of deflected particles ✓<br>reference to interference/diffraction/minimum/maximum/numbers of particles ✓ | *Allow "foil" instead of thin* |
| **b** | **ii** | $\lambda \propto \frac{1}{\sqrt{E}}$ ***OR*** $\lambda \propto \frac{1}{E}$ ✓<br>so high energy gives small $\lambda$ ✓<br>to match the small nuclear size ✓<br>***Alternative 2***<br>$E = hf$ /energy is proportional to frequency ✓<br>frequency is inversely proportional to wavelength/ $c = f\lambda$ ✓<br>to match the small nuclear size ✓<br>***Alternative 3***<br>higher energy means closer approach to nucleus ✓<br>to overcome the repulsive force from the nucleus ✓<br>so greater precision in measurement of the size of the nucleus ✓ | *Accept inversely proportional*<br>*Only allow marks awarded from **one** alternative* |
| **c** | | two analogous situations stated ✓<br>one element of the analogy equated to an element of physics ✓ | *eg: moving away from Earth is like climbing a hill where the contours correspond to the equipotentials*<br>*Atoms in an ideal gas behave like pool balls*<br>*The forces between them only act during collisions* |

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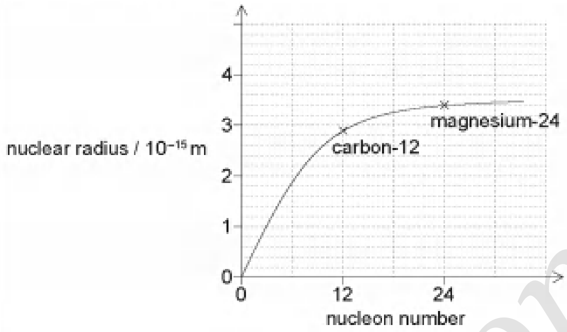
| d | i | $R = 2.7 \times 10^{-15} \times 2^{\frac{1}{3}}$ ✔<br>$3.4 - 3.5 \times 10^{-15}$ «m» ✔ | *Allow use of the Fermi radius from the data booklet* |
| d | ii | correctly plotted ✔ | *Allow ECF from (d)(i)* |
| d | iii | <u>single smooth curve</u> passing through both points with decreasing gradient ✔<br>through origin ✔ |  |