International Advanced Subsidiary Level

Physics

Specification

Assessment and Content Overview

Unit name & Paper code	% of IAS	% of IAL	Mark	Duration
Unit 1: **Mechanics & Materials** Written exam paper Paper code: WPH11/01	40	20	80	1 hour 30 minutes
Unit 2: **Waves & Electricity** Written exam paper Paper code: WPH12/01	40	20	80	1 hour 30 minutes
Unit 3: **Practical skills in Physics 1** Written exam paper Paper code: WPH13/01	20	10	50	1 hour 20 minutes

IAS exams will be held in:	October series next year
IAL exams will be held in:	October series year after next

Content tested in IAS exams	Unit 1, Unit 2 & Unit 3
Content tested in IAL exams	Unit 4, Unit 5 & Unit 6

Unit 1 & Unit 2	• The paper includes multiple-choice, short open, open-response, calculations and extended-writing questions. • The paper will include questions that target mathematics at Level 2 or above (see Appendix 6: Mathematical skills and exemplifications). A minimum of 32 marks will be awarded for mathematics at Level 2 or above. • Students will be expected to apply their knowledge and understanding to familiar and unfamiliar contexts.
Unit 3	• The paper includes short-open, open-response, calculations and extended-writing questions. • The paper will include questions that target mathematics at Level 2 or above (see Appendix 6: Mathematical skills and exemplifications). A minimum of 20 marks will be awarded for mathematics at Level 2 or above. • Students will be expected to apply their knowledge and understanding of practical skills to familiar and unfamiliar situations.

Unit 1 Mechanics & Materials	Unit 2 Waves & Electricity
1. SI base units	1. Basics of waves
2. Uniformly accelerated motion in one dimension	2. Principle of superposition
3. To interpret displacement-time, velocity-time and acceleration-time graphs (both uniform and non-uniform motion)	3. Diffraction
4. Vector resolution	4. Interference
5. Forces	5. Stationary waves
6. Momentum	6. Refraction
7. Moment of a force	7. Polarization
8. Work energy power efficiency	8. Ultrasound
9. Fluids	9. Photo electric effect
10. Hooke's law, young's modulus	10. Atomic spectra
	11. Drift velocity
	12. Circuit components
	13. Potential divider
	14. Internal resistance

Unit 1: Mechanics and Materials

IAS compulsory unit

Externally assessed

1.1 Unit description

Introduction	This unit covers mechanics and materials. This topic may be studied using applications that relate to mechanics, for example sports and to materials, for example spare-part surgery. This topic also enables students to develop practical and mathematical skills.
Practical skills	In order to develop their practical skills, students should be encouraged to carry out a range of practical experiments related to this topic. Possible experiments include strobe photography or the use of a video camera to analyse projectile motion, determine the centre of gravity of an irregular rod, investigate the conservation of momentum using light gates and air track, Hooke's law and the Young modulus experiments for a variety of materials.
Mathematical skills	Mathematical skills that could be developed in this topic include: plotting two variables from experimental data; calculating rate of change from a graph showing a linear relationship; drawing and using the slope of a tangent to a curve as a measure of rate of change; calculating or estimating, by graphical methods as appropriate, the area between a curve and the x-axis and realising the physical significance of the area that has been determined; distinguishing between instantaneous rate of change and average rate of change and identifying uncertainties in measurements; using simple techniques to determine uncertainty when data are combined; using angles in regular 2D and 3D structures with force diagrams and using sin, cos and tan in physical problems.

1.2 Assessment information

Some questions will assess knowledge and understanding of experimental methods.	• First assessment: January 2019. • The assessment is 1 hour and 30 minutes. • The assessment is out of 80 marks. • Candidates must answer all questions. • The paper may include multiple-choice, short open, open-response, calculations and extended-writing questions. • The paper will include questions that target mathematics at Level 2. A minimum of 32 marks will be awarded for mathematics at Level 2 or above in this paper. • Candidates will be expected to apply their knowledge and understanding to familiar and unfamiliar contexts. • Calculators may be used in the examination. Please see *Appendix 11: Use of calculators*.

1.3 Mechanics

This topic covers rectilinear motion, forces, energy and power. It may be studied using applications that relate to mechanics such as sports.

This unit includes many opportunities for developing experimental skills and techniques by carrying out more than just the core practical experiments.

Students will be assessed on their ability to:

1	be able to use the equations for uniformly accelerated motion in one dimension: $s = \frac{(u+v)t}{2}$ $v = u + at$ $s = ut + \frac{1}{2}at^2$ $v^2 = u^2 + 2as$
2	be able to draw and interpret displacement-time, velocity-time and acceleration-time graphs
3	know the physical quantities derived from the slopes and areas of displacement-time, velocity-time and acceleration-time graphs, including cases of non-uniform acceleration and understand how to use the quantities
4	understand scalar and vector quantities and know examples of each type of quantity and recognise vector notation
5	be able to resolve a vector into two components at right angles to each other by drawing and by calculation
6	be able to find the resultant of two coplanar vectors at any angle to each other by drawing, and at right angles to each other by calculation
7	understand how to make use of the independence of vertical and horizontal motion of a projectile moving freely under gravity
8	be able to draw and interpret free-body force diagrams to represent forces on a particle or on an extended but rigid body using the concept of *centre of gravity* of an extended body
9	be able to use the equation $\sum F = ma$, and understand how to use this equation in situations where *m* is constant (Newton's second law of motion), including Newton's first law of motion where $a = 0$, objects at rest or travelling at constant velocity *Use of the term 'terminal velocity' is expected.*
10	be able to use the equations for gravitational field strength $g = \frac{F}{m}$ and weight $W = mg$
11	**CORE PRACTICAL 1: Determine the acceleration of a freely-falling object**
12	know and understand Newton's third law of motion and know the properties of pairs of forces in an interaction between two bodies
13	understand that momentum is defined as $p = mv$

14	know the principle of conservation of linear momentum, understand how to relate this to Newton's laws of motion and understand how to apply this to problems in one dimension
15	be able to use the equation for the moment of a force, moment of force = Fx where x is the perpendicular distance between the line of action of the force and the axis of rotation
16	be able to use the concept of centre of gravity of an extended body and apply the principle of moments to an extended body in equilibrium
17	be able to use the equation for work $\Delta W = F\Delta s$, including calculations when the force is not along the line of motion
18	be able to use the equation $E_k = \frac{1}{2}mv^2$ for the kinetic energy of a body
19	be able to use the equation $\Delta E_{grav} = mg\Delta h$ for the difference in gravitational potential energy near the Earth's surface
20	know, and understand how to apply, the principle of conservation of energy including use of work done, gravitational potential energy and kinetic energy
21	be able to use the equations relating power, time and energy transferred or work done $P = \frac{E}{t}$ and $P = \frac{W}{t}$
22	be able to use the equations $\text{efficiency} = \frac{\text{useful energy output}}{\text{total energy input}}$ and $\text{efficiency} = \frac{\text{useful power output}}{\text{total power input}}$

1.4 Materials

This topic covers density, flow of liquids, Hooke's law, the Young modulus and elastic strain energy.

This topic should be studied using a variety of applications, for example making and testing food, engineering materials, spare-part surgery for joint replacement.

This unit includes many opportunities for developing experimental skills and techniques by carrying out more than just the core practical experiments.

Students will be assessed on their ability to:

23	be able to use the equation density $\rho = \frac{m}{V}$
24	understand how to use the relationship upthrust = weight of fluid displaced
25	a be able to use the equation for viscous drag (Stokes' Law), $F = 6\pi\eta rv$. b understand that this equation applies only to small spherical objects moving at low speeds with *laminar flow* (or in the absence of *turbulent flow*) and that viscosity is temperature dependent
26	**CORE PRACTICAL 2: Use a falling-ball method to determine the viscosity of a liquid**
27	be able to use the Hooke's law equation, $\Delta F = k\Delta x$, where k is the stiffness of the object
28	understand how to use the relationships • *(tensile or compressive) stress = force/cross-sectional area* • *(tensile or compressive) strain= change in length/original length* *Young modulus = stress/strain.*
29	a be able to draw and interpret force-extension and force-compression graphs b understand the terms limit of proportionality, elastic limit, yield point, elastic deformation and plastic deformation and be able to apply them to these graphs
30	be able to draw and interpret tensile or compressive stress-strain graphs, and understand the term *breaking stress*
31	**CORE PRACTICAL 3: Determine the Young modulus of a material**
32	be able to calculate the elastic strain energy E_{el} in a deformed material sample, using the equation $\Delta E_{el} = \frac{1}{2}F\Delta x$, and from the area under the force-extension graph *The estimation of area and hence energy change for both linear and non-linear force-extension graphs is expected.*

Unit 2: Waves and Electricity

IAS compulsory unit

Externally assessed

2.1 Unit description

Introduction	This topic covers waves and the particle nature of light and electric currents. This topic may be studied using applications that relate to electricity, for example space technology and to waves, for example medical physics. This topic also enables students to develop practical and mathematical skills.
Practical skills	In order to develop their practical skills, students should be encouraged to carry out a range of practical experiments related to this topic. Possible experiments include estimating power output of an electric motor, using a digital voltmeter to investigate the output of a potential divider and investigating current/voltage graphs for a filament bulb, thermistor and diode, determining the refractive index of solids and liquids, demonstrating progressive and stationary waves on a slinky.
Mathematical skills	Mathematical skills that could be developed in this topic include substituting numerical values into algebraic equations using appropriate units for physical quantities and applying the equation $y = mx + c$ to experimental data, using calculators to handle $\sin x$, identifying uncertainties in measurements and using simple techniques to determine uncertainty when data are combined.

2.2 Assessment information

- First assessment: June 2019.
- The assessment is 1 hour and 30 minutes.
- The assessment is out of 80 marks.
- Candidates must answer all questions.
- The paper may include multiple-choice, short open, open-response, calculations and extended-writing questions.
- The paper will include questions that target mathematics at Level 2. A minimum of 32 marks will be awarded for mathematics at Level 2 or above in this paper.
- Candidates will be expected to apply their knowledge and understanding to familiar and unfamiliar contexts.
- Calculators may be used in the examination. Please see *Appendix 11: Use of calculators*.

2.3 Waves and Particle Nature of Light

This topic covers the properties of different types of wave, including standing waves. Refraction, polarisation and diffraction are also included and the wave/particle nature of light. This topic should be studied by exploring the applications of waves, for example applications in medical physics or music.

This unit includes many opportunities for developing experimental skills and techniques by carrying out more than just the core practical experiments.

Students will be assessed on their ability to:

33	understand the terms amplitude, frequency, period, speed and wavelength
34	be able to use the wave equation $v = f\lambda$
35	be able to describe longitudinal waves in terms of pressure variation and the displacement of molecules
36	be able to describe transverse waves
37	be able to draw and interpret graphs representing transverse and longitudinal waves including standing/stationary waves
38	**CORE PRACTICAL 4: Determine the speed of sound in air using a 2-beam oscilloscope, signal generator, speaker and microphone**
39	know and understand what is meant by *wavefront, coherence, path difference, superposition, interference* and *phase*
40	be able to use the relationship between *phase difference* and *path difference*
41	know what is meant by a *standing/stationary* wave and understand how such a wave is formed, know how to identify nodes and antinodes
42	be able to use the equation for the speed of a transverse wave on a string $v = \sqrt{\frac{T}{\mu}}$
43	**CORE PRACTICAL 5: Investigate the effects of length, tension and mass per unit length on the frequency of a vibrating string or wire**
44	be able to use the equation for the intensity of radiation $I = \frac{P}{A}$
45	know and understand that at the interface between medium 1 and medium 2 $n_1 \sin \theta_1 = n_2 \sin \theta_2$ where refractive index is $n = \frac{c}{v}$
46	be able to calculate critical angle using $\sin C = \frac{1}{n}$

47	be able to predict whether total internal reflection will occur at an interface
48	understand how to measure the refractive index of a solid material
49	understand what is meant by plane polarisation
50	understand what is meant by diffraction and use Huygens' construction to explain what happens to a wave when it meets a slit or an obstacle
51	be able to use $n\lambda = d\sin\theta$ for a diffraction grating
52	**CORE PRACTICAL 6: Determine the wavelength of light from a laser or other light source using a diffraction grating**
53	understand how diffraction experiments provide evidence for the wave nature of electrons
54	be able to use the de Broglie equation $\lambda = \frac{h}{p}$
55	understand that waves can be transmitted and reflected at an interface between media
56	understand how a pulse-echo technique can provide information about the position of an object and how the amount of information obtained may be limited by the wavelength of the radiation or by the duration of pulses
57	understand how the behaviour of electromagnetic radiation can be described in terms of a wave model and a photon model, and how these models developed over time
58	be able to use the equation $E = hf$, that relates the photon energy to the wave frequency
59	understand that the absorption of a photon can result in the emission of a photoelectron
60	understand the terms 'threshold frequency' and 'work function' and be able to use the equation $hf = \phi + \frac{1}{2}mv_{max}^2$
61	be able to use the electronvolt (eV) to express small energies
62	understand how the photoelectric effect provides evidence for the particle nature of electromagnetic radiation
63	understand atomic line spectra in terms of transitions between discrete energy levels and understand how to calculate the frequency of radiation that could be emitted or absorbed in a transition between energy levels.

2.4 Electric Circuits

This topic covers the definitions of various electrical quantities, for example current, potential difference and resistance, Ohm's law and non-ohmic conductors, potential dividers, e.m.f. and internal resistance of cells and negative temperature coefficient thermistors.

This topic should be studied using applications such as space technology.

This unit includes many opportunities for developing experimental skills and techniques by carrying out more than just the core practical experiments.

Students will be assessed on their ability to:

64	understand that electric current is the rate of flow of charged particles and be able to use the equation $I = \frac{\Delta Q}{\Delta t}$
65	understand how to use the equation $V = \frac{W}{Q}$
66	understand that resistance is defined by $R = \frac{V}{I}$ and that Ohm's law is a special case when $I \propto V$ for constant temperature
67	(a) understand how the distribution of current in a circuit is a consequence of charge conservation (b) understand how the distribution of potential differences in a circuit is a consequence of energy conservation
68	be able to derive the equations for combining resistances in series and parallel using the principles of charge and energy conservation, and be able to use these equations
69	be able to use the equations $P = VI$, $W = VIt$ and be able to derive and use related equations, e.g. $P = I^2R$ and $P = \frac{V^2}{R}$
70	understand how to sketch, recognise and interpret current-potential difference graphs for components, including ohmic conductors, filament bulbs, thermistors and diodes
71	be able to use the equation $R = \frac{\rho l}{A}$
72	**CORE PRACTICAL 7: Determine the electrical resistivity of a material**
73	be able to use $I = nqvA$ to explain the large range of resistivities of different materials
74	understand how the potential along a uniform current-carrying wire varies with the distance along it
75	understand the principles of a potential divider circuit and understand how to calculate potential differences and resistances in such a circuit
76	be able to analyse potential divider circuits where one resistance is variable including thermistors and light dependent resistors (LDRs)

77	know the definition of *electromotive force (e.m.f.)* and understand what is meant by *internal resistance* and know how to distinguish between e.m.f. and *terminal potential difference*
78	**CORE PRACTICAL 8: Determine the e.m.f. and internal resistance of an electrical cell**
79	understand how changes of resistance with temperature may be modelled in terms of lattice vibrations and number of conduction electrons and understand how to apply this model to metallic conductors and negative temperature coefficient thermistors
80	understand how changes of resistance with illumination may be modelled in terms of the number of conduction electrons and understand how to apply this model to LDRs.

Unit 3: Practical Skills in Physics I

IAS compulsory unit

Externally assessed

3.1 Unit description

Introduction

Students are expected to develop experimental skills, and a knowledge and understanding of experimental techniques, by carrying out a range of practical experiments and investigations while they study Units 1 and 2.

This unit will assess students' knowledge and understanding of experimental procedures and techniques that were developed when they conducted these experiments.

Development of practical skills, knowledge and understanding

Students should carry out a variety of practical work during the IAS course to develop their practical skills. This should help them to gain an understanding and knowledge of the practical techniques that are used in experimental work.

In order to prepare students for the assessment of this unit, centres should give students opportunities to plan experiments, implement their plans, collect data, analyse their data and draw conclusions.

Experiments should cover a range of different topic areas and require the use of a variety of practical techniques.

3.2 Assessment information

- First assessment: June 2019.
- The assessment is 1 hour and 20 minutes.
- The assessment is out of 50 marks.
- Candidates must answer all questions.
- The paper may include short-open, open-response, calculations and extended-writing questions.
- The paper will include questions that target mathematics at Level 2. A minimum of 20 marks will be awarded for mathematics at Level 2 or above in this paper.
- Calculators may be used in the examination. Please see *Appendix 11: Use of calculators*.

3.3 Planning

Students will be expected to plan an experiment set by Pearson, although they will not be expected to carry it out.

Candidates will be assessed on their ability to:

Plan an experiment

- identify the apparatus required
- the range and resolution of measuring instruments including Vernier calipers (0.1mm) and micrometer screw gauge (0.01mm)
- discuss calibration of instruments, e.g. whether a meter reads zero before measurements are made
- describe how to measure relevant variables using the most appropriate instrument and correct measuring techniques
- identify and state how to control all other relevant variables to make it a fair test
- discuss whether repeat readings are appropriate
- identify health and safety issues and discuss how these may be dealt with
- discuss how the data collected will be used
- identify possible sources of uncertainty and/or systematic error and explain how these may be reduced or eliminated
- comment on the implications of physics (e.g. benefits/risks) and on its context (e.g. social/environmental/historical).

3.4 Implementation and measurements

Students will be given details of an experiment carried out by an inexperienced student. Results may be included.

Candidates will be assessed on their ability to:

Implementation and measurements

- comment on the number of readings taken
- comment on the range of measurements taken
- comment on significant figures
- check a reading that is inconsistent with other readings, e.g. a point that is not on the line of a graph – students may be shown a diagram of a micrometer that is being used to measure the diameter of a wire and be expected to write down the reading to the correct number of significant figures
- comment on how the experiment may be improved, possibly by using additional apparatus (e.g. to reduce errors) – examples may include using a set square to determine whether a ruler is vertical to aid the measurement of the extension of a spring.

3.5 Processing Results

Students will be provided with a set of experimental results that were obtained by a more-experienced student conducting an experiment.

Candidates will be assessed on their ability to:

Process results

- perform calculations, using the correct number of significant figures
- plot results on a graph using an appropriate scale
- use the correct units throughout
- comment on the relationship obtained from the graph
- determine the relationship between two variables or determine a constant with the aid of a graph, e.g. by determining the gradient using a large triangle
- suggest realistic modifications to reduce errors
- suggest realistic modifications to improve the experiment
- discuss uncertainties, qualitatively and quantitatively
- determine the percentage uncertainty in measurements for a single reading using **half** the resolution of the instrument **and** from multiple readings using the **half** range (students are **not** expected to compound percentage uncertainties).

Appendix 11: Use of calculators

Candidates may use a calculator in assessments for these qualifications. Centres are responsible for making sure that calculators used by their students meet the requirements given in the table below.

Candidates must be familiar with the requirements before their assessments for these qualifications.

<table>
<tr>
<td>Calculators must be:
• of a size suitable for use on a desk
• battery- or solar-powered
• free of lids, cases and covers that contain printed instructions or formulae.</td>
<td rowspan="2">Calculators must not:
• be designed or adapted to offer any of these facilities:
  ○ language translators
  ○ symbolic algebraic manipulation
  ○ symbolic differentiation or integration
  ○ communication with other machines or the internet
• be borrowed from another candidate during an examination for any reason*
• have retrievable information stored in them. This includes:
  ○ databanks
  ○ dictionaries
  ○ mathematical formulae
  ○ text.</td>
</tr>
<tr>
<td>The candidate is responsible for the following:
• the calculator’s power supply
• the calculator’s working condition
• clearing anything stored in the calculator.</td>
</tr>
</table>