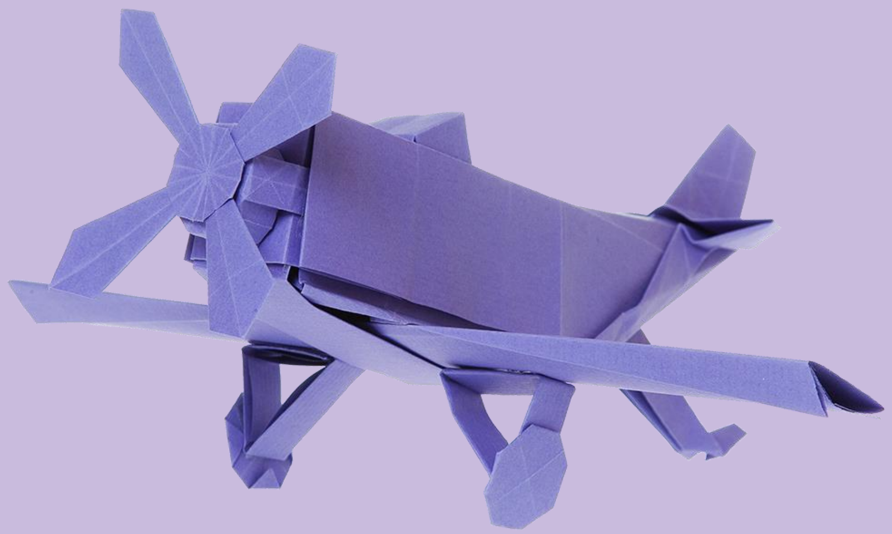
A Level Physics

Understanding our Exams

Course Code: 9PH0-24O3



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Aims and Objectives

- Look at how our question papers are designed to test the specification
- Understand how and why markers are standardised to mark exam papers
- See some example of mark schemes applied to recent exam questions
- Consider some strategies to improve how students respond to exam questions
- Address common issues and FAQs

Agenda

0–5 minutes	Welcome and introduction
5–10 minutes	The 10-stage process
10–45 minutes	Structure of the assessment
45–65 minutes	Mark Schemes
65–70 minutes	Comfort break
70–110 minutes	Applying Mark Schemes
110–115 minutes	Advice for students
115–120 minutes	Questions

Getting to Know You Polls

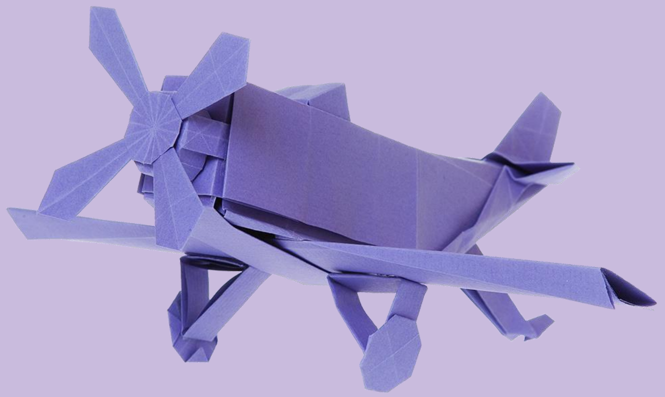
How long have you been teaching A Level Physics?

1. I’m new to teaching A Level Physics
2. 1–5 years
3. More than 5 years

How long have you been teaching Edexcel A Level Physics?

1. I’m new to teaching Edexcel A Level Physics
2. 1–5 years
3. More than 5 years

The 10-Stage Process



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Producing an Exam Paper

The following procedure is followed:

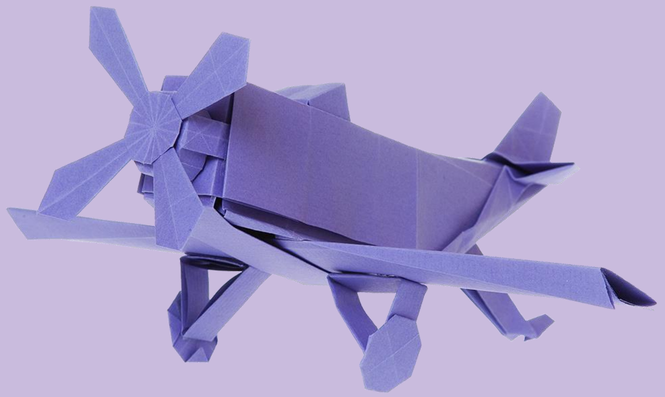
- Principal Examiner (PE) writes first draft of paper.
- First draft of paper is reviewed by Chair and Chief (of Examiners) and discussed with PE.
- Amended paper is sent out to revisers for comment.
- PE reviews revisers' comments and produces an amended paper ready for the Question Paper Evaluation Committee (QPEC) meeting.
- Question paper, mark scheme and assessment objective grid discussed at QPEC meeting and amendments made.

Producing an Exam Paper

The following procedure is followed:

- Post QPEC materials sent out to two scrutineers for comment.
- PE agrees amendments with Chair and Chief.
- Amended materials are sent for proof reading, and for final checking from a subject specialist.
- PE agrees amendments with Chair and Chief.
- Sample of paper is printed and checked for accuracy by PE together with the Chair and Chief.

Writing Questions: General Principles



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Producing an Exam Paper

Selecting topics for the questions:

- The topics chosen should allow questions to be set that assess items from the specification.
- The questions should cover a wide range of specification items.
- Most questions relate to a real-world context that links the question parts together.

Producing an Exam Paper

Selecting topics for the questions:

- Some topics lend themselves to short questions focused on a small number of specification items
- Other topics allow items from across the range of the specification to be combined, enabling longer questions to be used.
- If the paper includes multiple choice questions, these are likely to be light on context.

Producing an Exam Paper

Some questions:

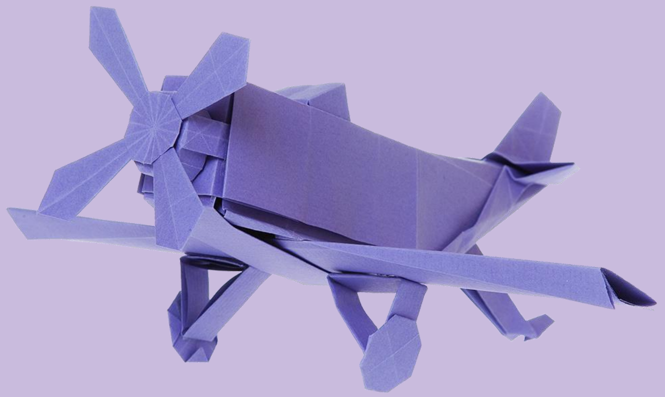
- require physics knowledge to be used in familiar contexts
- require physics knowledge to be used in unfamiliar contexts
- are directly based on the core practical experiments
- are based on the skills developed as a result of completing the core practical experiments.

Ramping

Ramping means that the difficulty increases progressively.

- Ramping occurs in individual questions
  - the level of demand increases throughout a question.
- Ramping also occurs across the whole paper.
  - the level of demand increases throughout the paper.
- Ramping within questions tends to be used to a greater extent in longer questions.
- Ramping allows all students a chance of gaining marks throughout the paper.

Writing Questions:
Rules and Regulations



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Rules and Regulations

- All exam boards must adhere to the regulatory framework set out by Ofqual.
- Ofqual monitors each board to ensure that their practice conforms to this framework.
- Physics examinations must include:
  - a minimum core Physics content
  - a minimum mathematical content
  - a balance between mathematical calculations and written explanations
  - opportunities to assess extended writing
  - the assessment of practical skills.

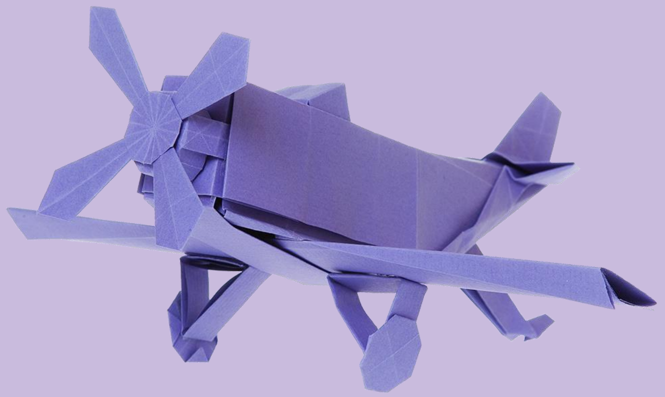
Physics and Maths Content

- The core Physics should comprise about 60% of the qualification.
- Mathematics at level 2 or above is built into some questions.
- Overall, a minimum of 40% of the total marks will be awarded for mathematics at Level 2 or above.

Grade Profile

- Each question or part of question is targeted at a particular grade
- The targets for a paper are approximately
  - 20% of the marks at grade A
  - 40% of the marks at grade C
  - 40% of the marks at grade E.
- This ensures that each paper is set at a consistent level of difficulty.
- This enables standards to be maintained year on year.

Writing Questions: Specifics



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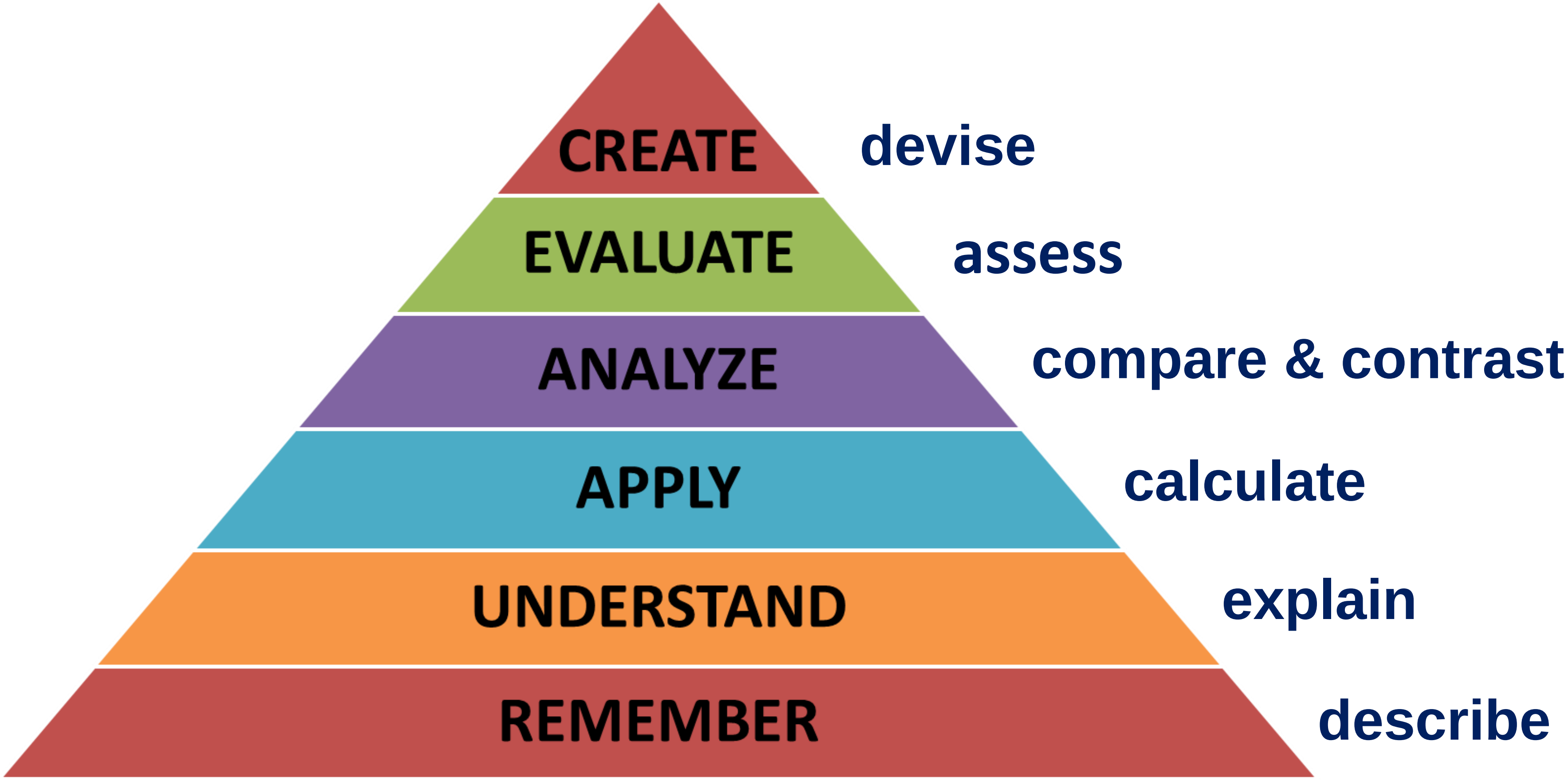
Command Words

- To help students understand how they should frame their answer, we use command words.
- The command words are used:
  - in the same way across all sciences
  - in the same way for A level as for GCSE.
- Command words always appear at the beginning of the sentence.
- Each command word signals a particular style of response.
- Candidates should be familiar with the style of response associated with each command word.

Command Words & Bloom's Taxonomy



Command Words

State the type of error she avoided by doing this.

Describe the procedure she should follow to determine an accurate value for the external diameter of the tube.

Explain the difference between the predicted time and the student's actual observations.

Discuss how the relevant conservation laws apply to this collision.

Calculate the percentage uncertainty in the mean value of ω.

Show that the energy per unit volume that would have to be absorbed by the seat belt is about $2 \times 10^8\,\mathrm{J\,m^{-3}}$.

Determine the specific heat capacity of aluminium.

Criticise the student's results.

Comment on whether the student's data is consistent with his initial determination of the focal length of the lens.

Assess the validity of the student's suggestion.

Accessibility

- Accessibility and language level are key factors when deciding upon final question wording.
- Information included in the question is restricted to the essential information required to answer the question.
- The level of language is monitored to ensure that all candidates should be able to read and understand the question.
- Contexts for questions are chosen to be inclusive to all candidates and to avoid reinforcing gender stereotypes.

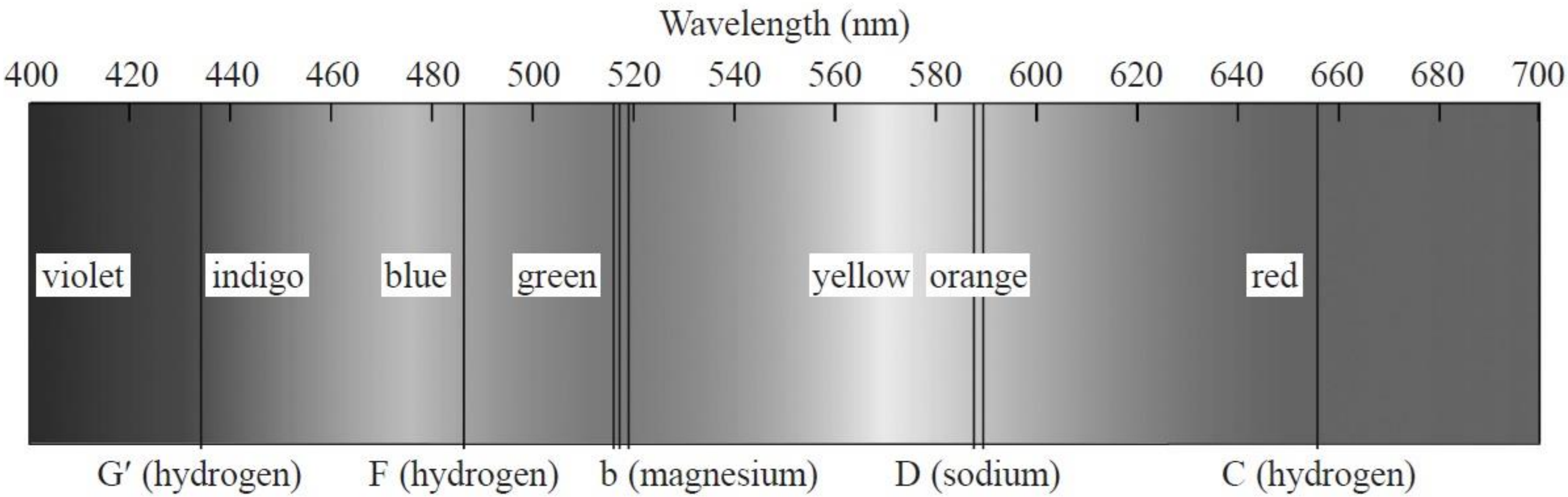
Assessment Objectives

AO1: Demonstrate knowledge and understanding of scientific ideas, processes, techniques and procedures.

- AO1 marks may be for
  - Recall of information
  - Use of an equation
  - Explanations of physical phenomena in standard situations
- AO1 marks account for about 32% of the marks across the whole qualification.

Example of AO1 Marks

(b) A spectrum of the visible light emitted by a particular star is shown.



(Source: © Universal Images Group North America LLC/Alamy Stock Photo)

(i) Light interacts with atoms as it passes through the atmosphere of the star.

Explain how this leads to the formation of the dark lines within the spectrum.

(4)

Example of AO1 Marks

An explanation that makes reference to the following points:

- Electrons / atoms exist in discrete/fixed/certain energy levels
  Or there are only a certain number of specific differences in energy levels of electrons / atoms
- (Absorbing) a photon causes an electron / atom to move to a higher energy level
  Or (Absorbing) a photon causes an electron / atom to become excited
- Photons are (only) absorbed when the photon energy is equal to the difference between energy levels
- Photon energy depends on frequency/wavelength, so photons of specific frequencies/wavelengths are absorbed, (producing dark lines)

Assessment Objectives

AO2: Apply knowledge and understanding of scientific ideas, processes, techniques and procedures

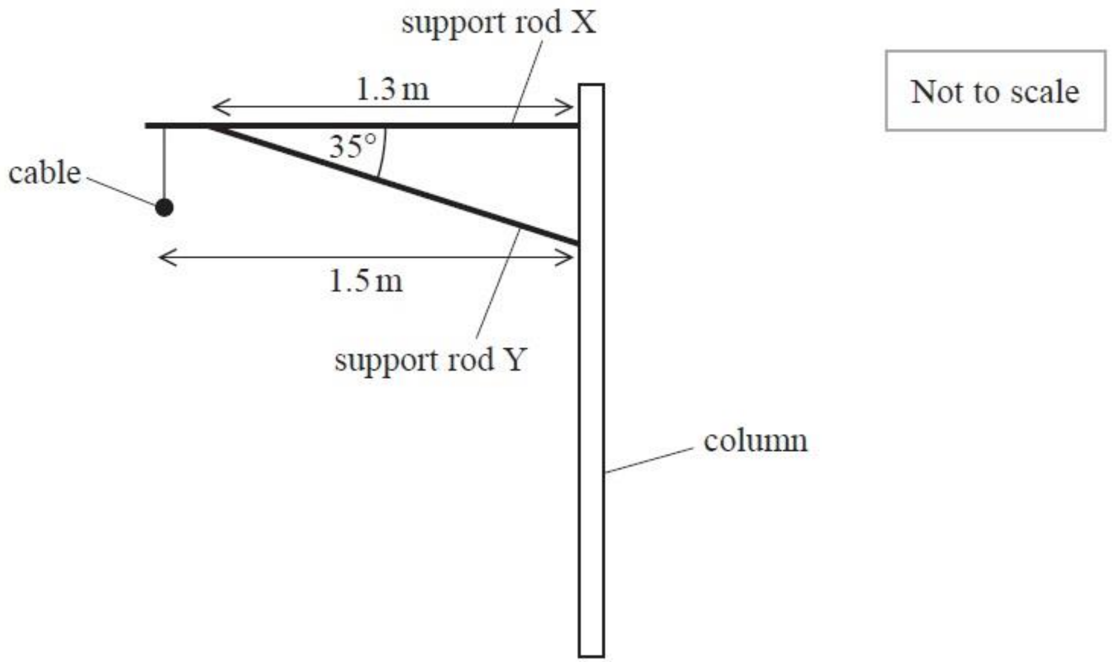
- ***in both a theoretical and practical context***
- ***and when handling qualitative and quantitative data***

- AO2 marks may be for
  - A correct calculation
  - An application of knowledge
- AO2 marks account for about 42% of the marks across the whole qualification.

Example of AO1 & AO2 Marks

14 Overhead electricity cables for railway lines are supported by structures like the one shown.

An electric cable of mass 45 kg is suspended from a support rod X. A second support rod Y is attached to X. X and Y are attached at one end to a column.



The masses of support rods X and Y are negligible.

(a) (i) Determine, by taking moments, the force exerted on rod X by rod Y.

(4)

Example of AO1 & AO2 Marks

Mark Scheme:

- Attempt to take moments around right hand end of X [distance of 1.5 m used with 45 Or 1.3 m used with *T*]
- Use of $W = mg$
- Correct component of *T* or perpendicular distance to *T*
- $T = 890$ N

Example of calculation

$45 \text{ kg} \times 9.81 \text{ N kg}^{-1} \times 1.5 \text{ m} = T \times 1.3 \text{ m} \times \sin 35$

$T = 888$ N

Example of AO2 Marks

15 A delta particle decays into a proton and a pion.

(ii) The mass of the proton is 939 MeV/c^2 and the mass of the pion is 139 MeV/c^2.

Explain why the sum of the masses of the two particles after the decay is not equal to the mass of the delta particle.

(3)

Mark Scheme:

- Calculates mass difference
  Or states (total) mass of decay products is less than mass of delta particle
- According to $\Delta E = \Delta mc2$
- becomes (extra) *E*k (between decay products)

Example of Calculation

939 + 139 = 1078

1232 – 1078 = 154(MeV/c^2)

Or 1232 is more than 1078(MeV/c^2)

Assessment Objectives

AO3: Analyse, interpret and evaluate scientific information, ideas and evidence, including in relation to issues,

- ***to make judgements and reach conclusions***
- ***and develop and refine practical design and procedures.***

- AO3 marks may require conclusions or judgements to be formed from qualitative or quantitative questions.
- AO3 marks account for about 26% of the marks across the whole qualification.

Example of AO3 Marks

7 The neon lamp shown is a glass bulb filled with neon gas at low pressure.

(b) When light from the neon lamp is incident upon a metal surface, electrons with a maximum speed of $2.68 \times 10^5\,\mathrm{m\,s^{-1}}$ are emitted from the surface.

The table shows the work functions of some metals.

Metal	Caesium	Potassium	Sodium
Work function / 10^{-19} J	3.36	3.68	3.84

Deduce which metal the light is incident upon.

frequency of light from the neon lamp = 5.56×10^{14} Hz

(4)

Example of AO3 Marks

Mark Scheme:

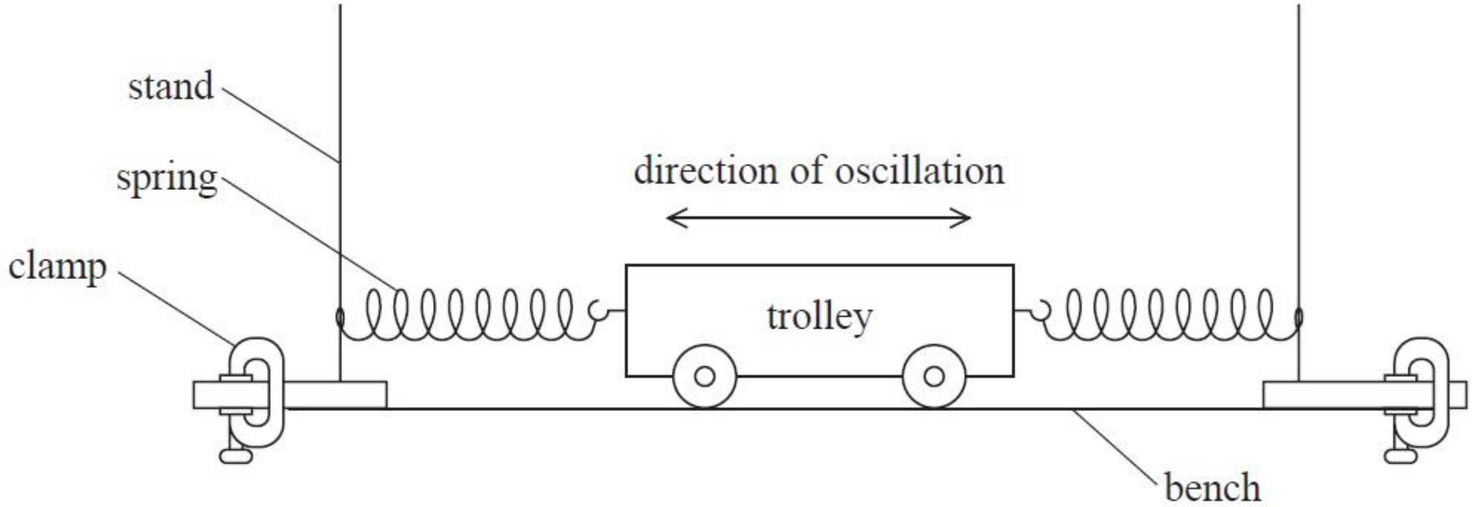
- Use of *E* = *h f*
- Use of *E*k = ½ mv^2
- Use of $hf = \phi + ½\, mv^2_{max}$
- $\phi = 3.36 \times 10^{-19}$ (J) so metal is caesium

<u>Example of calculation</u>

- $E = hf$ = 6.63×10^{-34} J s × 5.56×10^{14} J
- ∴ $E = 3.69 \times 10^{-19}$ J
- Max *E*k = ½ *mv2*
- = $0.5 \times 9.11 \times 10^{-31}$ kg × (2.68 × 105 m $s^{-1})^2$
- = 3.27×10^{-20} J
- ∴ $\phi = 3.69 \times 10^{-19}$ J $- 3.27 \times 10^{-20}$ J
- $\phi = 3.36 \times 10^{-19}$ J

Example of AO3 Marks

6 A student investigated the horizontal oscillations of a trolley between two springs, using the apparatus shown.



The student displaced the trolley from its equilibrium position. She then released the trolley and started a stopwatch. She stopped the stopwatch when the trolley had completed one oscillation.

(a) Describe how the method used by the student could be improved to determine a more accurate value of the time period.

(4)

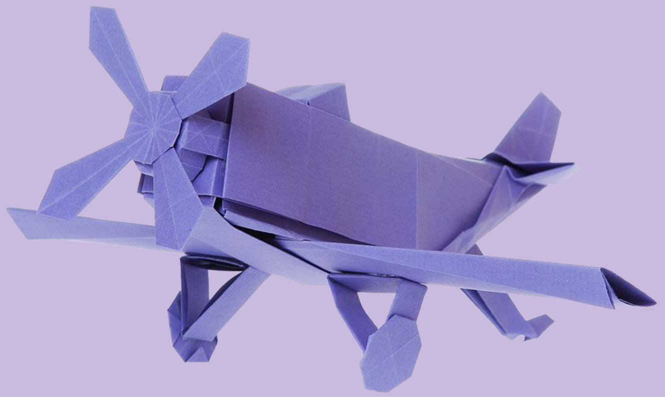
Example of AO3 Marks

Mark Scheme:

- Time a number of (complete) oscillations and divide this time by the number of (complete) oscillations
- Repeat measurement (of time) **and** determine a mean value
- Use a (fiducial) marker (so easier to see when trolley passes a particular point)
- Time from the mid-point of the oscillation
  Or Wait for oscillation to settle before starting to time

[Allow 1 mark for reference to using light gates and a data logger if no other marks awarded]

Mark Schemes



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Mark Schemes

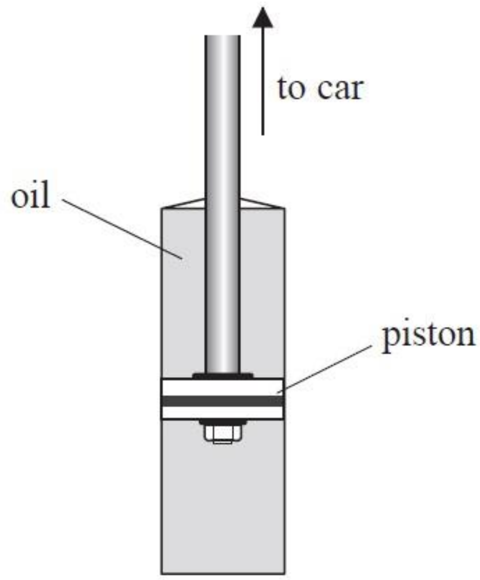
- Mark schemes are produced and amended as part of the 10-stage process.
- Once an exam paper has been sat, the Principal Examiner makes adjustments to the mark scheme to take into account candidates' responses.
- Examiners make notes as part of the standardisation process to assist them in their marking.

Mark Schemes

- As part of the standardisation process the mark scheme is explained to examiners.
- Examiners are then required to demonstrate that they can apply the mark scheme accurately before they are allowed to continue marking live scripts.
- The standardisation process includes a focus on responses that are on the cusp of gaining a mark, so that examiners are able to judge accurately when to award a mark.
- During live marking, examiners can send marginal responses to review to be marked by a more senior examiner.

Mark Schemes

(d) The oscillations are heavily damped by a piston in the suspension system. The piston moves within a cylinder filled with oil, as shown. The oil has a high viscosity.



Explain why using oil of high viscosity will produce heavy damping.

(3)

Mark Schemes

Original Scheme

An explanation that makes reference to the following points:

- Heavy damping so energy of oscillation is quickly dissipated to the oil
- High viscosity oil will mean a large resistive force applied to the oscillations
- When piston moves through a small displacement a large amount of work will be done

Published Scheme

An explanation that makes reference to the following points:

- High viscosity oil will mean a large resistive force applied to the oscillations [May refer to $F = 6\pi\eta r v$]
- (When piston moves) a large amount of work will be done [May refer to $\Delta W = F\Delta s$]
- (Heavy damping so) energy of oscillation is quickly dissipated to the oil

Mark Schemes

- As stated in published documents, mark schemes are applied positively.
- Candidates are rewarded for what they have shown they can do rather than penalised for omissions.
- However, it is important a response has clearly met the marking point before the mark can be awarded.
- Marking points can sometimes seem pedantic in terms of the detail and precision required.
- However, bear in mind that the purpose of a mark scheme is to separate out students so that grades can be awarded fairly.

Extended Open Response Questions

- These questions are sometimes referred to as linkage questions.
- This is because marks are awarded for the ability to
  - structure the answer logically,
  - show how the points that made are related or follow on from each other.
- These questions are always worth 6 marks, and are indicated by an asterisk (*) next to the question.
- Up to 4 marks are available for correct physics, and up to 2 marks are available for a logical structure with good linkage of ideas.

Example of AO1 Marks (EOR Question)

17 Scientists can analyse light from stars that has passed through a diffraction grating.

*(a) Explain the pattern produced when a mixture of blue and red light, from the same source, passes through a diffraction grating.

(6)

This question assesses a student's ability to show a coherent and logically structured answer with linkages and fully-sustained reasoning.

Marks are awarded for indicative content and for how the answer is structured and shows lines of reasoning.

The table opposite shows how the marks should be awarded for indicative content.

IC points	IC mark	Max linkage mark available	Max final mark
6	4	2	6
5	3	2	5
4	3	1	4
3	2	1	3
2	2	0	2
1	1	0	1
0	0	0	0

Example of AO1 Marks

Indicative content:

IC1(Waves from different slits) undergo superposition/interference

IC2 Constructive (interference) where path difference = $n\lambda$
Or Constructive (interference) where in phase

IC3 (Bright) lines seen where constructive interference

[accept spots/lines/fringes maxima – colour reference to red/blue mix]

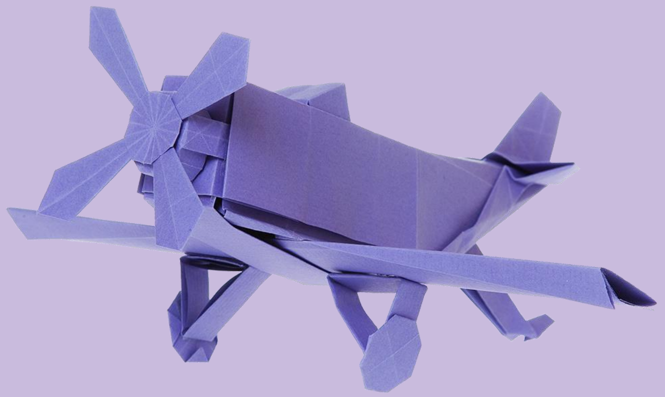
IC4 Central maximum/line due to mixture of red and blue light

[accept purple/violet/magenta/mauve]

IC5 $n\lambda = d\sin\theta$, so the angle/spacing of lines is larger for greater wavelength

IC6 Blue wavelength shorter than red, so next blue spot closer than red spot to centre spot

Applying Mark Schemes



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Marking Example A

14 The fuel used in a camping stove is butane, which is stored in a canister as shown.

Some of the butane in the canister is in a liquid state, and some is a gas.

(b) The pressure inside the canister is 220 kPa and the temperature of the gas is 21 °C.

(i) The canister is in the shape of a cylinder of length 0.23 m and radius 0.11 m.

Calculate the number of molecules of butane gas in the canister.

Assume the volume of liquid butane inside the canister is negligible.

(4)

Mark Scheme (Example A)

- Use of $V = \pi r^2 l$
- Use of $pV = NkT$
- Conversion of ^{o}C to K
- $N = 4.7 \times 10^{23}$

<u>Example of calculation</u>

$V = \pi \times 0.112\ (\text{m})^2 \times 0.23(\text{m}) = 8.74 \times 10^{-3}\ \text{m}^3$

$T = 21\ ^{o}\text{C} + 273 = 294\ \text{K}$

$2.2 \times 10^5\ \text{Pa} \times 8.7 \times 10^{-3}\ \text{m}^3 = N \times 1.38 \times 10^{-23}\text{J K}^{-1} \times 294\ \text{K}$

$N = 4.74 \times 10^{23}$

Response 1

(b) The pressure inside the canister is 220 kPa and the temperature of the gas is 21 °C.

(i) The canister is in the shape of a cylinder of length 0.23 m and radius 0.11 m. A

Calculate the number of molecules of butane gas in the canister.

Assume the volume of liquid butane inside the canister is negligible.

(4)

$pV = NkT$

$(220 \times 10^3) \times \frac{4}{3}\pi r^3 h = N \times 1.38 \times 10^{-23} \times (21 + 273)$

$N = \frac{pV}{kT}$

$= \frac{(220 \times 10^3) \times \frac{4}{3}\pi 0.11^3 \times 0.23}{1.38 \times 10^{-23} \times (21 + 273)}$

$= 2.2 \times 10^{22}$ molecules

Number of molecules of butane gas = 2.2×10^{22}

Response 2

(b) The pressure inside the canister is 220 kPa and the temperature of the gas is 21 °C.

(i) The canister is in the shape of a cylinder of length 0.23 m and radius 0.11 m.

Calculate the number of molecules of butane gas in the canister.

Assume the volume of liquid butane inside the canister is negligible.

(4)

~~$pV = \frac{1}{3} Nm\langle c^2 \rangle$~~

~~$(220\times10^3)(0.23)(0.11)(\pi(0.11)^2) = \frac{1}{3} N($~~

~~$pV = NR$~~ $pV = NkT$

$(220\times10^3)(0.23)(\pi(0.11)^2) = N(1.38\times10^{-23})(21)$

$N = \frac{(220\times10^3)(0.23)(\pi(0.11)^2)}{(1.38\times10^{-23}) ~~(1923)~~ (21)}$

$= 6.64\times10^{24}$ molecules (3sf)

Number of molecules of butane gas = 6.6×10^{24}

Response 3

(b) The pressure inside the canister is 220 kPa and the temperature of the gas is 21 °C.

(i) The canister is in the shape of a cylinder of length 0.23 m and radius 0.11 m.

Calculate the number of molecules of butane gas in the canister.

Assume the volume of liquid butane inside the canister is negligible.

(4)

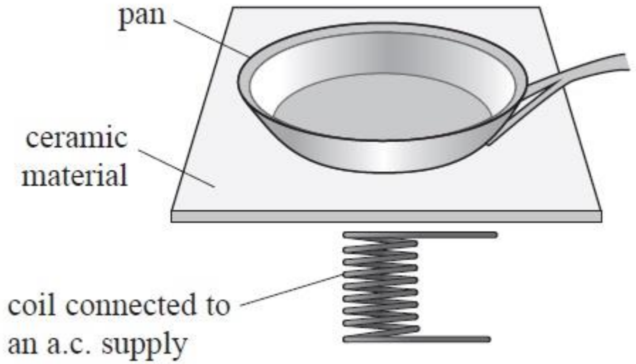
$PV = NkT$ $\quad P = 220 \times 10^3\ Pa,\ T = 21 + 273,\ V = 0.23 \times \pi (0.11)^2 = 8.74 \times 10^{-3} m$

$N = \frac{PV}{kT} = \frac{(220 \times 10^3)(8.74 \times 10^{-3})}{(1.38 \times 10^{-23})(21+273)} = 4.74 \times 10^{23}$ molecules (3s.f.)

Number of molecules of butane gas = 4.74×10^{23} (3s.f.)

Marking Example B

11 An induction hob consists of a coil beneath a sheet of ceramic material. The coil is connected to an alternating current (a.c.) supply as shown.



(a) A steel pan containing water is placed on the induction hob.

Explain why the pan becomes hot when the supply is switched on.

(4)

Mark scheme:

An explanation that makes reference to the following points:

- current (in coil) produces a magnetic field/flux
- (a.c.) leads to changing (magnetic) field/flux through pan
- induces an emf in pan
- leads to current (in pan because it is an electrical conductor)

MP4 dependent on MP2,; MP2, MP3 and MP 4 must relate to the pan

Response 1

(a) A steel pan containing water is placed on the induction hob.

Explain why the pan becomes hot when the supply is switched on.

(4)

• a.c Supply generates a Changing magnetic field which causes a Change in flux linkage

• Through faradays law, this induces an emf through the coil $\epsilon = \frac{d(N\phi)}{dt}$

• Therefore a current flows through the coil

• The current causes the temperature of the coil to rise, in turn the ceramic material conducts heat allowing the Pan to get hotter.

Response 2

(a) A steel pan containing water is placed on the induction hob.

Explain why the pan becomes hot when the supply is switched on.

(4)

Because when the supply turns on the alternating current creates a changing magnetic field. This magnetic field cuts through the steen pan meaning a current is induced ~~depending on how the frequency of the AC supply~~ the plate ~~can~~ will get hotter as current increases.

Response 3

(a) A steel pan containing water is placed on the induction hob.

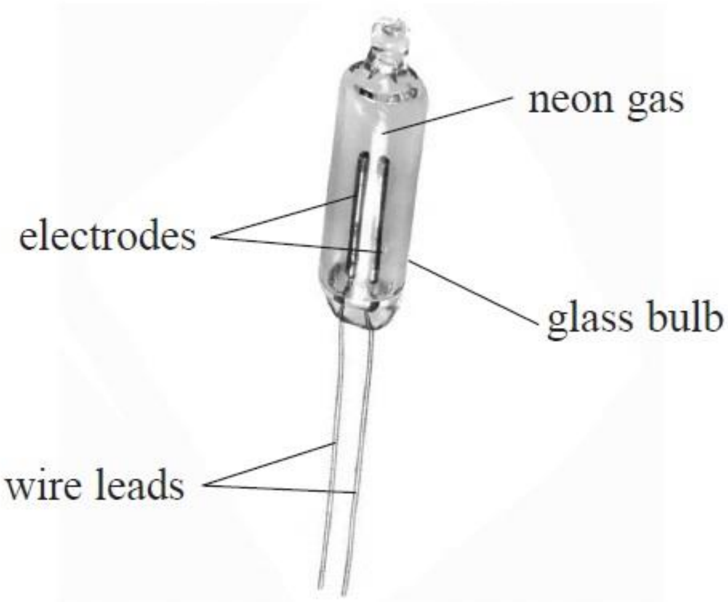
Explain why the pan becomes hot when the supply is switched on.

(4)

- The AC supply ~~induces~~ throughout the coil induces a magnetic field, in which the ~~e~~ emf is proportional to the rate of change of flux linkage.
- The AC causes a change in flux linkage.
- The magnetic field induces an emf in the pan, despite no electricity passing through the ceramic material, as a result the changing magnetic field induces an emf in the pan which produces a current in the pan.
- the pan heats up due to the high resistance of the pan.

Marking Example C

7 The neon lamp shown is a glass bulb filled with neon gas at low pressure.



(Source: https://media.digikey.com/Photos/Visual%20Communications%20Company%20VCC/A1A.JPG)

*(a) When in use, the neon gas between the electrodes emits electromagnetic radiation.

Explain why this happens when there is an electric current between the electrodes.

(6)

Mark Scheme (Example C)

IC1 The electric current is a movement of electrons (between the electrodes)
[Accept "charge carriers" for "electrons"]

IC2 The electrons collide with neon atoms
[Accept "interact" for "collide"]

IC3 Energy is transferred to the neon atoms (in the collisions)

IC4 Electrons in the neon (atoms) are promoted to higher energy states
Or electrons in neon (atoms) are excited

IC5 (After a short time) electrons in the neon (atoms) return to their normal/ground state
Or electrons in neon (atoms) de-excite

IC6 When an electron returns to a lower energy state it emits a photon (of electromagnetic radiation)

IC points	IC mark	Max linkage mark available	Max final mark
6	4	2	**6**
5	3	2	**5**
4	3	1	**4**
3	2	1	**3**
2	2	0	**2**
1	1	0	**1**
0	0	0	**0**

Response 1

*(a) When in use, the neon gas between the electrodes emits electromagnetic radiation.

Explain why this happens when there is an electric current between the electrodes.

(6)

The electrodes will produces a potential difference between them. So charge carries will go from one electrode to the other when a current flows. Current flowing will produce heat which will give the neon gas more energy. If the energy provided by this heat is big enough it will cause electrons to move up to higher energy levels (excitation). ~~If this~~ Eventually the electrons will de-excite and move back down to a lower energy level. When this ~~Happens~~ happens the energy ~~excession~~ difference from the higher level to lower level is released from the electron as a discreet packet of electro- ~~mag~~ magnetic radiation (photon). The Energy is directly proportional to the frequency of radiation emmitted.

Response 2

*(a) When in use, the neon gas between the electrodes emits electromagnetic radiation.

Explain why this happens when there is an electric current between the electrodes.

(6)

I

electrons emit electromagnetic radiation when they fall ~~betw~~ down discrete energy levels, (~~dexcital~~ deexcitation). The ~~current between the electrodes provides~~ As current travels through the wire and heats it up, ~~the resistance of the the~~ the number of charge carriers released increase(d)s which means resistence increases and ∴ ~~Vot~~ potential differnce increases. Electrons absorb energy and ~~jump up~~ are excited to higher discrete energy levels and then ~~fall to~~ deexcite while emitting electromagnetic radiation. electrons have discrete energy levels

$pV = NnT$

Response 3

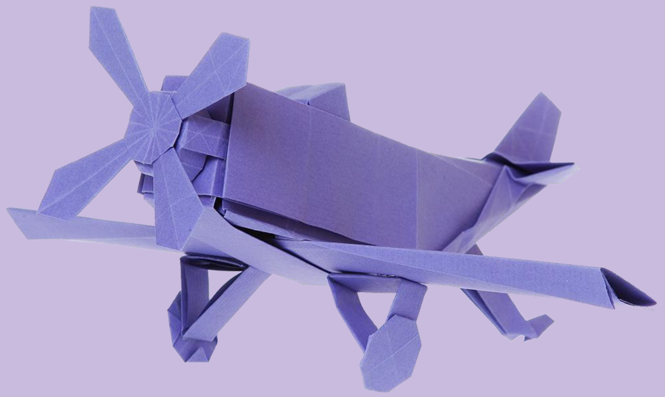
*(a) When in use, the neon gas between the electrodes emits electromagnetic radiation.

Explain why this happens when there is an electric current between the electrodes.

(6)

The current causes the electrons in the Neon atoms to excite and go to a higher energy level and when they fall back down they release energy in the form of photons. ~~Thus so~~ The frequency of the light is proportional to ~~it~~ its energy. E = hf. Only certain the energy is equal to the difference in energy levels and because there are a ~~discrete~~ limited no of discrete energy levels ~~therefore~~ only certain energy changes are possible hence only certain wavelengths of light are released. Hence when the current excites the electrons in the neon gas certain wavelengths of electromagnetic radiation are released

Advice for Candidates



Advice for Candidates

- Prepare for the exam by working through past paper questions.
- Read the Principal Examiner’s report to identify common pitfalls.
- Good exam technique is vital - a few extra marks can make all the difference to your grade
- Don’t leave your dreams in **RUINS**:
    - **Read** the question carefully
    - **Underline** keywords
    - **Identify** the command word
    - **Note** the available marks
    - **Structure** your answer clearly

Advice for Candidates

- **Read the question carefully** – a common error is **not** to answer the question given.
- **Underline keywords** – this may be useful in identifying starting points for your response.
- **Identify the command word** – this should direct you to the intended type of response.
- **Note the available marks** – a rule of thumb is to spend about a minute per mark on average.
- **Structure your answer clearly:**
    - In a calculation you may get marks for your working, even if your final answer is incorrect
    - In an explanation, there may be marks for a clear structure.

Your Subject Advisor

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