

# **Understanding Assessment and Improving Delivery in IAL Physics**

**Linkage questions**

**Mark schemes**

## UNIT 1

### Question 1

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

Number of indicative marking points seen in answer	Number of marks awarded for indicative marking points
6	4
5-4	3
3-2	2
1	1
0	0

#### Indicative content

- The idea that the rope is under tension
- Team A exerts a force on the rope and due to N3 the rope exerts a force on Team A
- Force of rope on team A > frictional force for Team A
- Team A now has a resultant force (to the right)
- Team A accelerates (to the right) due to N1/2
- (This is because) the frictional force between Team B and the ground is larger Or Team B applies a greater force (on the rope) than team A

The following table shows how the marks should be awarded for structure and lines of reasoning

	Number of marks awarded for structure of answer and sustained line of reasoning
Answer shows a coherent and logical structure with linkages and fully sustained lines of reasoning demonstrated throughout	2
Answer is partially structured with some linkages and lines of reasoning	1
Answer has no linkages between points and is unstructured	0

Accept tension for 'force of rope on team'

MP4: accept 'unbalanced' for 'resultant'

Accept converse for MP6 but a reference to both Team A and Team B is required for MP6

## Question 2

Acceptable Answers	Additional guidance	Mark								
<p>This question assesses a student's ability to show a coherent and logically structured answer with linkages and fully-sustained reasoning.</p> <p>Marks are awarded for indicative content and for how the answer is structured and shows lines of reasoning.</p> <p><b>Indicative Content</b></p> <ul style="list-style-type: none"><li>Band does <b>not</b> obey Hooke's law Or there is a non-linear relationship between force and extension (1)</li><li>(The band is elastic so) the extension returns to zero when the force is removed or size/shape is unchanged (1)</li><li>For a given force the extension when loading is less than when unloading or for the same extension more force required when loading (1)</li><li>Area under the loading curve is greater than the unloading curve Or Loading increases the elastic strain energy (of the band) (1)</li><li>The band absorbs more energy when being loaded than it releases when unloaded Or Unloading: some strain energy transferred by heating (1)</li><li>Energy released by heating represented by the area between the lines (1)</li></ul>	<p>The following table shows how the marks should be awarded for structure and lines of reasoning</p> <table><tr><th></th><th>Number of marks awarded for structure of answer and sustained line of reasoning</th></tr><tr><td>Answer shows a coherent and logical structure with linkages and fully sustained lines of reasoning demonstrated throughout</td><td>2</td></tr><tr><td>Answer is partially structured with some linkages and lines of reasoning</td><td>1</td></tr><tr><td>Answer has no linkages between points and is unstructured</td><td>0</td></tr></table>		Number of marks awarded for structure of answer and sustained line of reasoning	Answer shows a coherent and logical structure with linkages and fully sustained lines of reasoning demonstrated throughout	2	Answer is partially structured with some linkages and lines of reasoning	1	Answer has no linkages between points and is unstructured	0	6
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<b>Total for question 9</b>		<b>6</b>								

### Question 3

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

Number of indicative marking points seen in answer	Number of marks awarded for indicative marking points
6	4
5 - 4	3
3 - 2	2
1	1
0	0

#### Indicative content

- At greater speed, the drag force is greater
- Resultant force decreases **Or** acceleration decreases
- When the rocket is started the (resultant) force/thrust increases
- The mass/weight of the car decreases as fuel is used up
- Increasing the acceleration (for a given applied force)
- When the brakes are applied, there is a deceleration  
**Or** when the brakes are applied the resultant force is in the opposite direction  
**Or** deceleration (due to drag forces) decreases due to smaller drag forces acting on the car at lower speeds

The following table shows how the marks should be awarded for structure and lines of reasoning

	Number of marks awarded for structure of answer and sustained line of reasoning
Answer shows a coherent and logical structure with linkages and fully sustained lines of reasoning demonstrated throughout	2
Answer is partially structured with some linkages and lines of reasoning	1
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#### Question 4

Additional guidance	Mark																				
<p>This question assesses a student's ability to show a coherent and logically structured answer with linkages and fully-sustained reasoning.</p> <p>Marks are awarded for indicative content and for how the answer is structured and shows lines of reasoning.</p> <p>The following table shows how the marks should be awarded for indicative content.</p> <table border="1"> <thead> <tr> <th>Number of indicative marking points seen in answer</th><th>Number of marks awarded for indicative marking points</th></tr> </thead> <tbody> <tr> <td>6</td><td>4</td></tr> <tr> <td>5 - 4</td><td>3</td></tr> <tr> <td>3 - 2</td><td>2</td></tr> <tr> <td>1</td><td>1</td></tr> <tr> <td>0</td><td>0</td></tr> </tbody> </table> <p><b>Indicative content</b></p> <ul style="list-style-type: none"> <li>• Sphere A applies a force to sphere B (on impact)</li> <li>• According to Newtons third law Sphere B will apply an (equal and) opposite force to Sphere A</li> <li>• This force opposes the motion of Sphere A</li> <li>• Sphere A decelerates, according to N2</li> <li>• The (resultant) force on sphere B accelerates B</li> <li>• The forces/impulse acting (on the spheres) are equal so the change in speeds/momentum are the same for each sphere.</li> </ul>	Number of indicative marking points seen in answer	Number of marks awarded for indicative marking points	6	4	5 - 4	3	3 - 2	2	1	1	0	0	<p>The following table shows how the marks should be awarded for structure and lines of reasoning</p> <table border="1"> <thead> <tr> <th></th><th>Number of marks awarded for structure of answer and sustained line of reasoning</th></tr> </thead> <tbody> <tr> <td>Answer shows a coherent and logical structure with linkages and fully sustained lines of reasoning demonstrated throughout</td><td>2</td></tr> <tr> <td>Answer is partially structured with some linkages and lines of reasoning</td><td>1</td></tr> <tr> <td>Answer has no linkages between points and is unstructured</td><td>0</td></tr> </tbody> </table>		Number of marks awarded for structure of answer and sustained line of reasoning	Answer shows a coherent and logical structure with linkages and fully sustained lines of reasoning demonstrated throughout	2	Answer is partially structured with some linkages and lines of reasoning	1	Answer has no linkages between points and is unstructured	0
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## UNIT 2

### Question 5

	<p><b>Indicative content</b></p> <ul style="list-style-type: none"><li>• This is a diffraction/interference pattern</li><li>• Electrons behave as waves</li><li>• As speed/momentum increases the circles get smaller</li><li>• <math>n\lambda = d\sin\theta</math> used to justify that as <math>\theta</math> decreases <math>\lambda</math> decreases</li><li>• Refers de Broglie equation (<math>\lambda = h/p</math>) to confirm that as speed/momentum increases, wavelength decreases.</li><li>• Crystal has a regular/layered structure</li></ul>	<p><b>PP2</b> Do not credit 'electrons behave as waves or particles' on its own</p> <p><b>PP3</b> accept circles get condensed for circles get smaller</p> <p><b>PP4</b> do not credit use of equation to justify <math>\lambda</math> same size as gaps in crystal or to measure the gaps in the graphite</p> <p><b>PP6</b> small gaps at uniform distances/lengths Or accept that graphite is made up of more than a single crystal</p>
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## Question 6

Acceptable Answers	Additional Guidance	Mark																												
<p>This question assesses a student's ability to show a coherent and logical structured answer with linkage and fully-sustained reasoning.</p> <p>Marks are awarded for indicative content and for how the answer is structured and shows lines of reasoning.</p> <p>The following table shows how the marks should be awarded for indicative content.</p> <table><tr><th>Number of indicative points seen in answer</th><th>Number of marks awarded for indicative points</th></tr><tr><td>6</td><td>4</td></tr><tr><td>5-4</td><td>3</td></tr><tr><td>3-2</td><td>2</td></tr><tr><td>1</td><td>1</td></tr><tr><td>0</td><td>0</td></tr></table> <p><b>Particle model</b></p> <ul style="list-style-type: none"><li>One photon interacts with one electron</li><li>And each photon has energy proportional to the frequency, Or reference to <math>E=hf</math></li><li>The electron is emitted (instantly) only if the energy of the photon is greater than the work function (of the metal) Or The electron is emitted (instantly) only if the energy of the photon is greater than the energy needed for an electron to break free (from metal surface)</li><li>Any photon energy over and above the work function is gained by the electron as kinetic energy</li></ul> <p><b>Wave model</b></p> <ul style="list-style-type: none"><li>It would be expected that the energy of the electron would build up and eventually be emitted.</li><li>The (kinetic) energy of the (emitted) electrons would depend on the intensity of the wave (and not the frequency)</li></ul>	Number of indicative points seen in answer	Number of marks awarded for indicative points	6	4	5-4	3	3-2	2	1	1	0	0	<p>The following table shows how the marks should be awarded for structure and lines of reasoning</p> <table><tr><th></th><th>Number of marks awarded for structure and lines of reasoning</th></tr><tr><td>Answer shows a coherent and logical structure with linkage and fully sustained lines of reasoning demonstrated throughout</td><td>2</td></tr><tr><td>Answer is partially structured with some linkages and lines of reasoning</td><td>1</td></tr><tr><td>Answer has no linkage between points and is unstructured</td><td>0</td></tr></table> <p><b>Linkage marks</b></p> <table><tr><th>Indicative content points</th><th>Possible linkage marks</th></tr><tr><td>0, 1</td><td>0</td></tr><tr><td>2, 3</td><td>1</td></tr><tr><td>4, 5, 6 with points from both models</td><td>2</td></tr></table>		Number of marks awarded for structure and lines of reasoning	Answer shows a coherent and logical structure with linkage and fully sustained lines of reasoning demonstrated throughout	2	Answer is partially structured with some linkages and lines of reasoning	1	Answer has no linkage between points and is unstructured	0	Indicative content points	Possible linkage marks	0, 1	0	2, 3	1	4, 5, 6 with points from both models	2	6
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## Question 7

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 following table shows how the marks should be awarded for structure and lines of reasoning

Number of indicative points seen in answer	Number of marks awarded for indicative points
6	4
5-4	3
3-2	2
1	1
0	0

### Indicative content

- (As  $V$  increases) acceleration/velocity/energy of electrons increases
- greater energy transfer in collisions with lattice / ions
- increasing the temperature of metal/filament/ions
- amplitude of vibrations of lattice/ ions increases
- collision (rate) between lattice /ions and electrons increases  
Or shorter distance between collisions  
Or greater chance of collision
- due to the increase in resistance, current doesn't increase in proportion to potential difference  
Or due to the increase in resistance the ratio of  $I/V$  decreases

The following table shows how the marks should be awarded for structure and lines of reasoning

	Number of marks awarded for structure and lines of reasoning
Answer shows a coherent and logical structure with linkage and fully sustained lines of reasoning demonstrated throughout	2
Answer is partially structured with some linkages and lines of reasoning	1
Answer has no linkage between points and is unstructured	0

Accept charge carriers for electrons and only penalise once for omission of charge carriers or lattice ions

### Linkage marks

Number of indicative content points awarded	Possible linkage marks
0, 1	0
2, 3	1
4, 5, 6	2

**MP1 don't award for 'increased rate of flow'**

**MP2 to award mark there must be the idea of increased/greater energy transfer between electrons and ions**



## Question 8

Acceptable Answers	Additional guidance												
<p>This question assesses a student's ability to show a coherent and logical structured answer with linkage and fully-sustained reasoning.</p> <p>Marks are awarded for indicative content and for how the answer is structured and shows lines of reasoning.</p> <p>The following table shows how the marks should be awarded for indicative content.</p> <table border="1"> <thead> <tr> <th>Number of indicative points seen in answer</th><th>Number of marks awarded for indicative points</th></tr> </thead> <tbody> <tr> <td>6</td><td>4</td></tr> <tr> <td>5-4</td><td>3</td></tr> <tr> <td>3-2</td><td>2</td></tr> <tr> <td>1</td><td>1</td></tr> <tr> <td>0</td><td>0</td></tr> </tbody> </table> <p><b>Indicative Content</b></p> <ul style="list-style-type: none"> <li>Two waves travelling in opposite directions (1)</li> <li>Superpose / interfere (1)</li> <li>Constructive (interference) if waves in phase (1) Or Constructive (interference) if path difference = <math>n\lambda</math></li> <li>Destructive (interference) if waves in antiphase (1) Or destructive (interference) if path difference = <math>(n + \frac{1}{2})\lambda</math> (1)</li> <li>Nodes are formed from points of destructive (interference) or antinodes are formed from points of constructive (interference) (1)</li> <li>Nodes are points with min amplitude and antinodes are points with max amplitude (1)</li> </ul>	Number of indicative points seen in answer	Number of marks awarded for indicative points	6	4	5-4	3	3-2	2	1	1	0	0	
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6	4												
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## UNIT 4

### Question 9

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Number of IC points	Possible linkage marks																												
0, 1	0																												
2, 3	1																												
4, 5, 6	2																												

## Question 10

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 following table 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

Indicative content:

- (Maximum/Initial) current is equal to battery emf divided by  $R$   
Or current as switch closed  
Or current as complete circuit  
Or current due to battery
- Coil rotates
- (movement of) coil "cuts/changes" (magnetic) flux (linkage) / field
- Which induces an emf (according to Faraday's law)
- Opposes original emf/current according to Lenz's law  
Or current reduced as effect opposes change
- The faster the coil rotates the larger this (back) emf/effect the smaller the current

ic3 needs a link to coil moving  
ic4 depends on ic3

## Question 11

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 shows how the marks should be awarded for indicative content and structure and lines of reasoning.

Number of indicative marking points seen in answer	Number of marks awarded for indicative marking points
6	4
5–4	3
3–2	2
1	1
0	0

	Number of marks awarded for structure of answer and sustained line of reasoning
Answer shows a coherent and logical structure with linkages and fully sustained lines of reasoning demonstrated throughout	2
Answer is partially structured with some linkages and lines of reasoning	1
Answer has no linkages between points and is unstructured	0

### Indicative content:

1. Removing the magnet from the ring changes the magnetic flux (linked with the ring)
2. This induces an e.m.f. (in the ring)
3. E.m.f. causes a current in the ring
4. Which produces a magnetic field
5. The magnetic fields interact/combine
6. This opposes the change, causing an attractive force **to** act

IC Points	IC Mark	Max linkage mark avail.	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

IC1: accept references to flux cutting

Alternative indicative content for IC4 – IC5

4. The current is in the magnetic field produced by the magnet
5. The current experiences a magnetic force

## UNIT 5

### Question 12

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 shows how the marks should be awarded for indicative content and structure and lines of reasoning.

Number of indicative marking points seen in answer	Number of marks awarded for indicative marking points
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5-4	3
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#### Indicative content:

1. As the temperature of the gas increases the (average) speed/ $E_k$  of the atoms increases
2. Greater speed/ $E_k$  so the momentum of the atoms increases
3. The rate/frequency of collision of atoms with the container walls increases Or the time between collisions with the walls decreases
4. The rate of change of momentum at the walls increases
5. Rate of change of momentum is equal to the force
6. Pressure is  $\frac{\text{force}}{\text{area}}$  and the force (on the walls) is greater

IC Points	IC Mark	Max linkage mark avail.	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

IC3 and IC4 must include a mention of the walls/container

### Question 13

#### Acceptable Answers

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

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3	2	1	3
2	2	0	2
1	1	0	1
0	0	0	0

#### Indicative content

- The pendulums have the same length, so they have time period/frequency.
- The first pendulum causes forced oscillations of the second pendulum.
- The driving frequency equals the natural frequency.
- Resonance occurs, so there is a maximum transfer of energy so amplitude increases until all energy is transferred.
- The second pendulum then acts as the driver for the first pendulum **Or** The process repeats with energy transfer from B to A.
- When the lengths differ the driving frequency is not the natural frequency so little energy is transferred.

## Question 14

Table for awarding marks and linkage marks as in previous question:

### Indicative content

- 720 Hz is the natural frequency of the bowl
- The generator/hand causes forced/driven oscillations
- When they don't match the natural frequency they are quiet because little/less energy is transferred
- The loudness (at 720 Hz) is because of resonance
- (Resonance occurs when) the driving frequency is equal/similar to the natural frequency
- (When resonance occurs) there is maximum transfer of energy so the amplitude is maximum  
Or (When resonance occurs) there is maximum transfer of energy so the amplitude increases

Do not accept 'resonant frequency' for 'natural frequency'