

**GCE**

**Applied Science**

Unit **G635**: Working Waves

Advanced GCE

**Mark Scheme for June 2018**

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All examiners are instructed that alternative correct answers and unexpected approaches in candidates' scripts must be given marks that fairly reflect the relevant knowledge and skills demonstrated.

Mark schemes should be read in conjunction with the published question papers and the report on the examination.

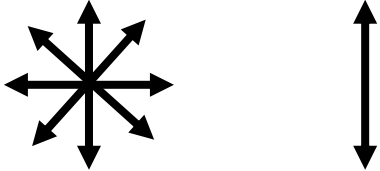
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## Annotations

<b>Annotation</b>	<b>Meaning</b>
<b>REJECT</b>	Answers which are not worthy of credit
<b>IGNORE</b>	Statements which are irrelevant
<b>ALLOW</b>	Answers that can be accepted
( )	Words which are not essential to gain credit
—	Underlined words must be present in answer to score a mark
<b>ECF</b>	Error carried forward
<b>AW</b>	Alternative wording
<b>ORA</b>	Or reverse argument

Question		Answer	Mark	Guidance
1	(a)	42 (cm) ✓	1	
1	(b)	<p><b>[0 marks]</b> response not worthy of credit.</p> <p><b>[1-2 marks]</b> Candidate demonstrates a limited knowledge wave motion, speed and its measurement</p> <p>For 1 mark at least one valid point For 2 marks at least two valid points</p> <p>The answer may not be clearly set out</p> <p><b>[3 marks]</b> Candidate demonstrates understanding of wave motion, speed and its measurement</p> <p>For 3 marks at least three valid points</p> <p>The answer will be set out in a manner that is easy to follow, but may contain one or two errors or omissions in content</p> <p><b>[4-5 marks]</b> Candidate demonstrates a high level of knowledge and understanding of wave motion, speed and its measurement</p> <p>For 4 marks at least four valid points For 5 marks at least five valid points</p> <p>The answer will be set out <b>clearly and logically</b></p>	5	<p>Valid points:</p> <p>variations of the vertical displacement at a point or along the pool</p> <p style="padding-left: 40px;">Description of oscillations /Gradually Increases/decreases ✓ Increases/decreases by 42 cm /amplitude ✓</p> <p>speed measurement:</p> <p><b>Either:</b></p> <p style="padding-left: 40px;">Measure distance between two points along the pool/ direction. ✓ Start stop-watch/timing device as wave passes first point, /Measure time to travel between the two points ✓ Stop stop-watch/timing device as wave passes second point ✓</p> <p style="padding-left: 40px;">Refinement, e.g. two observers to avoid parallax error, /measurement to a third point to check speed constant, /large space between points ✓ Divide distance by time ✓</p> <p><b>Or:</b></p> <p style="padding-left: 40px;">Measure/find frequency ✓ Explanation of how to measure frequency (By counting the waves passing (a point) in 1 s / in a given time and dividing by time) ✓ Measure /find wavelength ✓ Explanation of how to measure wavelength (Distance between two crest/ two troughs / two equivalent points on successive waves) ✓ Refinement e.g. Distance between n points and dividing by n ✓ <math>v=f\lambda</math> ✓</p> <p>Repeat and average ✓</p>

Question			Answer	Mark	Guidance
1	(c)	(i)	<p><u>Nodes</u> and <u>antinodes</u> ✓</p> <p>Peaks/troughs do not move along the pool /do not progress Or 'always maximum amplitude' / 'always zero amplitude' (at a particular point) Or nodes always at rest, antinodes always oscillate with max amplitude Or Vertical/ up and down motion only <b>of wave</b> ✓</p>	<p>1</p> <p>1</p>	<p><b>ALLOW</b> Diagram of suitable labelled with at least one N and one A in correct places.</p> <p><b>REJECT</b> Vertical/ up and down motion only <b>of water</b></p>
		(ii)	<p>Frequency/period (of the air input) ✓</p> <p>Depth of water /speed /velocity of wave✓</p>	<p>1</p> <p>1</p>	
<b>Total</b>				<b>[10]</b>	

Question		Answer	Mark	Guidance
2	(a)	<p>Light which oscillates in only one, (transverse) direction/Plane</p> <p>Or</p> <p>Light which oscillates in only one direction at right angles to the wave direction ✓</p>	1	<p><b>ALLOW</b> diagram for either or both MPs</p>  <p><b>DO NOT ALLOW</b> “move” /”travel” /”go” for “oscillates”</p>
2	(b)	<p>Reflections (gradually) appear (until rotated 90 degrees) ✓</p> <p>Then gradually disappear again when rotated a further 90 degrees, / a total of 180 degrees ✓</p>	1 1	<p>“Trees” for “reflections”</p>
<b>Total</b>			[3]	

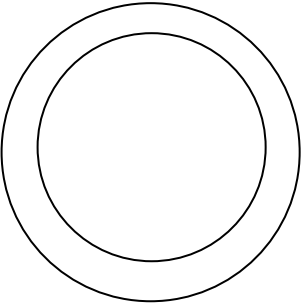
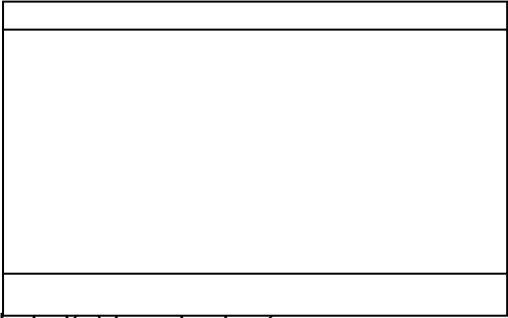
Question			Answer	Mark	Guidance
3	(a)		A: Ultraviolet B: Visible C: Infra red ✓	1	<b>ALLOW</b> X-rays/ $\gamma$ Rays for 'A'
3	(b)	i	Smooth curve higher in the centre than the sides. ✓  Peak between 400 and 1000 nm ✓	1  1	If more than one line drawn <b>ALLOW</b> each marking point if ALL lines meet the criteria for that point. (Unless annotated to clearly show which line to look at)
3	(b)	ii	Any two from:  Lower /less power /intensity (at all wavelengths) ✓  Peak /curve further to the right ✓  Minimum wavelength being further to right/greater ✓	2	<b>ALLOW</b> peak /curve further to red /infrared / higher wavelength (end) for 2 <sup>nd</sup> MP  <b>ALLOW</b> 1 mark for description of light from 2500 K source, e.g. warmer/redder/yellower/less blue/dimmer light. <b>IGNORE</b> black
3	(b)	iii	Cool white has peak in short wavelength end/ Warm white has peak in long wavelength of the visible spectrum ✓  Cool white contains more blue/ Warm white contains less blue/_more red ✓	1  1	
			<b>Total</b>	[7]	

Question		Answer	Mark	Guidance
4	(a)	Appropriate example e.g. Poor connection/ short circuit /internal damage ✓	1	For first mark answer must relate to electrical application. <b>IGNORE</b> vague response e.g. “wiring” alone  <b>ALLOW</b> some parts hotter when running correctly with brief explanation of why (e.g. heat sink/ heater in hair drier)
		Hotter/ colder or more/less IR emitted, near fault ✓	1	
4	(b)	False colours/ different shades of grey ✓	1	
		Brightness / colours correspond/related to temperature/ e.g. Brighter/whiter/redder/different colour near hotter part/faulty component ✓	1	
4	(c)	Can check apparatus while it is working/ no need to touch / dismantle apparatus/ avoid touching live wires / safer <b>or</b> Early warning of problem before it breaks/catches fire ✓	1	



Question		Answer	Mark	Guidance
4	(d)	<p>Spatial resolution:</p> <p>how well a thermal imaging camera can distinguish between objects at slightly different places/ separation of points which can be distinguished/ can distinguish between points close together ✓</p> <p>Indicated by number of pixels/image size divided by number of pixels/ 240x180 (pixels) ✓</p> <p>Thermal resolution:</p> <p>how well a thermal imaging camera can distinguish between objects at slightly different temperatures/ can distinguish between points at close temperatures ✓</p> <p>(+) 0.05 °C ✓</p>	<p>1</p> <p>1</p> <p>1</p> <p>1</p>	
<b>Total</b>			[9]	

Question			Answer	Mark	Guidance
5	(a)	i	Top Box: Laser ✓ Bottom Box: Photodiode ✓	1 1	<b>ALLOW LED</b>
		ii	<b>[0 marks]</b> response not worthy of credit.  <b>[1-2 marks]</b> Candidate demonstrates a limited knowledge of total internal reflection and refractive index  For 1 mark at least one valid point For 2 marks at least two valid points  The answer may not be clearly set out  <b>[3-4 marks]</b> Candidate demonstrates understanding of total internal reflection and refractive index  For 3 marks at least three valid points For 4 marks at least four valid points  The answer will be set out in a manner that is easy to follow, but may contain one or two errors or omissions in content  <b>[5-6 marks]</b> Candidate demonstrates a high level of knowledge and understanding of total internal reflection and refractive index  For 5 marks at least five valid points For 6 marks at least five valid points  The answer will be set out <b>clearly and logically</b>	<b>6</b>	Valid points (some may be met by a diagram):  (In (Optical) fibres:)  Light is reflected (as it goes along the fibre) ✓  (Light does not escape due to) Total Internal reflection /TIR ✓  Refractive index of air/ cladding is less than that of glass /core <b>Or</b> TIR occurs when light travelling in a more dense medium meets a less dense medium /wtte✓  Mention of critical angle ✓  If angle of incidence (inside glass) is > critical angle no light can escape. ✓  In Window glass angle of incidence (inside glass) is (normally) < critical angle light can escape ✓  Angle of incidence is angle between ray and the normal ✓  Light passing though (glass-air / core-cladding interface) is refracted ✓

Question			Answer	Mark	Guidance
5	(b)	i	Suitable diagram ✓ e.g.	1	 <b>Or</b> 
			Label(s) to indicate ✓ <b>Either:</b> outer layer has a lower refractive index <b>Or</b> Core inner and cladding outer	1	

Question			Answer	Mark	Guidance
5	(b)	ii	(Glass has a) gradual change of refractive index ✓	1	<b>ALLOW</b> optical density but not just density
			Decreases from centre to outside ✓	1	<b>ALLOW</b> density
5	(b)	iii	<p>Any <b>three</b> from:</p> <p>step-index optical fibres:            (multimode dispersion caused because) some rays arrive later than others ✓            light rays that follow longer paths /with more reflections take longer ✓            causing broadening/ degradation of pulses ✓</p> <p>(graded-index optical fibres):            Rays follow curved paths ✓            Faster further from axis ✓            Light with longer path length travels faster ✓            Signal all arrives at the same time ✓            Less distortion ✓            Greater distance between repeater stations ✓</p>	3	If candidate does not make clear whether answer is about step or graded–index fibres, assume answer refers to graded
5	(c)		<u>Coherent</u> ✓	1	
5	(d)	i	Refractive Index (of glass)✓	1	
5	(d)	ii	Critical Angle ✓	1	

Question			Answer	Mark	Guidance
5	(d)	iii	Critical Angle goes up as Refractive Index goes down ✓ $\text{Sin}C = \frac{1}{n}$ <b>Or</b> $\text{Sin\_Critical\_angle} = \frac{1}{\text{refractive\_index}} \checkmark$	1          1	Can be implied by equation
<b>Total</b>				[20]	

Question		Answer	Mark	Guidance
6	(a)	Many users/people/calls, /large population ✓	1	
6	(b)	Uplink: signal sent from phone/ user to mast/base station <b>and</b> Downlink: signal sent from mast/base station to phone/ user ✓	1	<b>ALLOW</b> mast to base station/ provider/etc.  <b>ALLOW</b> base station/ provider/etc to mast
6	(c)	full duplex: users can speak and listen/ send and receive (data) at same time as with <b>mobile phones</b> <b>and</b> half duplex: users take it in turns to speak and listen/ send and receive (data) as with <b>CB radios</b> ✓	1	<b>ALLOW</b> full duplex: uses two frequencies as with mobile phones  <b>ALLOW</b> half duplex uses one frequency as with CB radios



Question		Answer	Mark	Guidance	
6	(g)	$V = f\lambda$		Stated or implied	
		<b>Or</b> velocity/ speed = frequency x wavelength ✓	1		
		$\lambda = \frac{3.0 \times 10^8}{2.6 \times 10^9}$ ✓	1		
		$\lambda = 0.12$ (m to 2 sf) ✓	1	Correct rearrangement, conversion of GHz and substitution required  Correct rounding and sig. figs required <b>ALLOW</b> ecf from incorrect conversion of GHz and substitution required e.g. $\lambda = \frac{3.0 \times 10^8}{2.6 \times 10^6} = 120$ (m to 2 sf) $\lambda = \frac{3.0 \times 10^8}{2.6 \times 10^3} = 120\,000$ or $1.2 \times 10^5$ (m to 2 sf) $\lambda = \frac{3.0 \times 10^8}{2.6} = 120\,000\,000$ or $1.2 \times 10^8$ (m to 2 sf)	
6	(h)	Analogue: (Signal) varies continuously ✓	1		
		Digital: discrete/ whole values ✓	1		
6	(i)	i	Binary (numbers) are made up of 1s and 0s ✓	1	<b>ALLOW</b> 'two values' as AW for 0 and 1?
			Binary numbers are to the base 2/ digital numbers can be to any base ✓	1	



Question			Answer	Mark	Guidance
6	(i)	ii	(First set best)		<b>ALLOW</b> samples are too far apart
			Second set has too few samples/not sampled often/frequently enough ✓	1	
			Third set samples are not at regular intervals /are uneven/irregular ✓	1	
6	(j)		Can use telephone and internet at same time ✓	1	<b>ALLOW</b> e.g. "more data can be transmitted each second" or "greater/faster rate of data transfer"
			Greater data capacity ✓	1	
			<b>Total</b>	[18]	

Question			Answer	Mark	Guidance
7	(a)	i	Air fat soft tissue bone metal  All correct ✓ ✓ 3 correct 1 mark	2	
7	(a)	ii	Any <b>four</b> points from:  Left diagram represents narrow beam / Right diagram represents broad beam ✓  Pinhole makes beam narrow/ Pinhole acts as point source ✓  Narrow beam light from a point on object does not spread out/ all reaches the same point on the screen ✓  Narrow beam sharp image ✓  Broad beam light from a point on object does spread out/ reaches the more than one point on the screen ✓  Broad beam fuzzy/blurry image ✓	4	Not just better

Question			Answer	Mark	Guidance
7	(a)	iii	Any <b>two</b> points from:  Plates made of <u>lead</u> ✓  Scattered X-rays stopped by plates/ grid ORA ✓  grid produces beam where rays are parallel to each other ✓  Only unscattered X-rays reach film/ detector ✓	2	
7	(a)	iv	Phosphorescent ✓  Dose /dosage ✓  Digital ✓  Storage/display / imaging /viewing ✓	1  1  1  1	<b>ALLOW</b> fluorescent / luminescent / photoluminescent  <b>ALLOW</b> exposure  <b>ALLOW</b> electronic /electrical  <b>ALLOW</b> processing /analysis/ diagnosis
7	(b)	i	The tracer is cleared from the body soon after an imaging process/ patient has less exposure to radiation/radiation in the body for less time ✓	1	Expect some reference to radiation, dose, tracer etc.

Question			Answer	Mark	Guidance
7	(b)	ii	Physical half-life: Time taken for half the active nuclei to decay ✓	1	<b>ALLOW</b> Time taken for half the radioactivity to be halved <b>REJECT</b> half of the life of the nucleus  Must imply removal in some way
			Biological half-life: Time taken for half the active nuclei to be excreted/ removed from body or wtte ✓	1	
7	(b)	iii	Overall /Effective half life is combination of both processes (occurring together) ✓	1	<b>ALLOW</b> “combination” to be implied by any arithmetic processing of the $T_p$ and $T_b$  Equation scores <b>both</b> marks  $\frac{1}{T_p} + \frac{1}{T_b}$ <b>or</b> $\frac{1}{.25} + \frac{1}{1}$ <b>or</b> $\frac{1}{6} + \frac{1}{24}$ scores <b>first</b> mark
			Two processes combined are quicker than either of them ✓ <b>Or:</b> $\frac{1}{T_e} = \frac{1}{T_p} + \frac{1}{T_b}$	1	
7	(b)	iv	Collimator: to allow only parallel rays/ rays in one direction, to reach detector / absorbs scattered (gamma) rays ✓	1	
			photomultiplier tubes: to convert light to electric signal / amplify the signal ✓	1	

Question		Answer	Mark	Guidance
7	(c)	Switch off X-ray machine ✓	1	<b>REJECT</b> protective clothing unless made of Lead
		Lead /concrete shielding of Gamma-ray source/keep distance ✓	1	
7	(d)	Produced in different ways/ different properties/ uses ✓	1	Implied by example
		Example ✓ e.g. X-ray: rapid deceleration of electrons/ Excitation of innermost electrons in atoms  Gamma-rays: Disintegration of radioactive atomic Nuclei /product of radioactive decay  Gamma more damaging/ ionising / penetrating/ have higher energy/ than X- rays X-rays more useful for routine imaging /diagnosis Gamma rays more useful for therapy	1	
<b>Total</b>			[23]	

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 **Cambridge  
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