

Cambridge O Level

PHYSICS**5054/22**

Paper 2 Theory

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MARK SCHEME

Maximum Mark: 80

Published

This mark scheme contains the instructions and marking guidance that our examiners used to mark candidate responses for this component.

Before they start marking, examiners complete a standardisation process. They review a range of candidate responses and discuss the mark scheme in detail to agree which answers can and cannot be accepted. Examiners award marks where it is clear that candidate responses have met the requirements of the mark scheme. These requirements may vary between different components or different versions of the same component, depending on the exact requirements of the question and the candidate responses seen during the standardisation process.

Sometimes, our mark schemes may allow marks to be awarded to responses which contain elements that are factually incorrect or for content not covered by the syllabus. We do this in response to the demands of a specific question to support candidates and make sure that our assessments are fair. However, these allowances should not be used as a guide for teaching and learning.

We cannot discuss the mark scheme with schools, and we recommend that schools read the mark scheme together with the assessment material and the Principal Examiner Report for Teachers.

This document consists of **18** printed pages.

General marking principles

All examiners must apply these marking principles when marking candidate responses.

1	Examiners must award marks for each response in line with: - the specific content defined in the mark scheme - the specific skills defined in the mark scheme or in the level descriptions - the standard of response required as exemplified by the standardisation scripts.
2	Examiners must award whole marks (not half marks, or other fractions).
3	Examiners must award marks positively . This means that: - marks are not deducted for errors or omissions - marks are awarded for correct/valid answers as defined in the mark scheme and also for other valid answers which go beyond the scope of the syllabus and mark scheme referring to your team leader as appropriate - the quality of spelling, punctuation and grammar are judged only when the mark scheme indicates that these features are specifically assessed in the question. However, the meaning of all responses must be unambiguous.
4	Examiners must consistently apply the requirements of the mark scheme and any rules for what to do when candidates have not followed instructions correctly.
5	Examiners must use the full range of marks defined in the mark scheme, unless limited by the quality of the candidate responses seen.
6	Examiners must award marks according to the mark scheme and must not award marks with grade thresholds or grade descriptions in mind.

Science-Specific Marking Principles

1	Examiners should consider the context and scientific use of any keywords when awarding marks. Although keywords may be present, marks should not be awarded if the keywords are used incorrectly.
2	The examiner should not choose between contradictory statements given in the same question part, and credit should not be awarded for any correct statement that is contradicted within the same question part. Wrong science that is irrelevant to the question should be ignored.
3	Although spellings do not have to be correct, spellings of syllabus terms must allow for clear and unambiguous separation from other syllabus terms with which they may be confused (e.g. ethane / ethene, glucagon / glycogen, refraction / reflection).
4	The error carried forward (ecf) principle should be applied, where appropriate. If an incorrect answer is subsequently used in a scientifically correct way, the candidate should be awarded these subsequent marking points. Further guidance will be included in the mark scheme where necessary and any exceptions to this general principle will be noted.
5	<u>'List rule' guidance</u> For questions that require <i>n</i> responses (e.g. State two reasons ...): • The response should be read as continuous prose, even when numbered answer spaces are provided. • Any response marked <i>ignore</i> in the mark scheme should not count towards <i>n</i>. • Incorrect responses should not be awarded credit but will still count towards <i>n</i>. • Read the entire response to check for any responses that contradict those that would otherwise be credited. Credit should not be awarded for any responses that are contradicted within the rest of the response. Where two responses contradict one another, this should be treated as a single incorrect response. • Non-contradictory responses after the first <i>n</i> responses may be ignored even if they include incorrect science.

6 Calculation specific guidance

Correct answers to calculations should be given full credit even if there is no working or incorrect working, **unless** the question states 'show your working'.

For questions in which the number of significant figures required is not stated, credit should be awarded for correct answers when rounded by the examiner to the number of significant figures given in the mark scheme. This may not apply to measured values.

For answers given in standard form (e.g. $a \times 10^n$) in which the convention of restricting the value of the coefficient (a) to a value between 1 and 10 is not followed, credit may still be awarded if the answer can be converted to the answer given in the mark scheme.

Unless a separate mark is given for a unit, a missing or incorrect unit will normally mean that the final calculation mark is not awarded. Exceptions to this general principle will be noted in the mark scheme.

7 Guidance for chemical equations

Multiples / fractions of coefficients used in chemical equations are acceptable unless stated otherwise in the mark scheme.

State symbols given in an equation should be ignored unless asked for in the question or stated otherwise in the mark scheme.

Annotations guidance for centres

Examiners use a system of annotations as a shorthand for communicating their marking decisions to one another. Examiners are trained during the standardisation process on how and when to use annotations. The purpose of annotations is to inform the standardisation and monitoring processes and guide the supervising examiners when they are checking the work of examiners within their team. The meaning of annotations and how they are used is specific to each component and is understood by all examiners who mark the component.

We publish annotations in our mark schemes to help centres understand the annotations they may see on copies of scripts. Note that there may not be a direct correlation between the number of annotations on a script and the mark awarded. Similarly, the use of an annotation may not be an indication of the quality of the response.

The annotations listed below were available to examiners marking this component in this series.

Annotations

Annotation	Meaning
	information missing or insufficient for credit
	used to highlight parts of an extended response
	evaluation attempted
	benefit of the doubt given
	contradiction in response, mark not awarded
	incorrect point or mark not awarded
	error carried forward applied
	incorrect or insufficient point ignored while marking the rest of the response
	two statements are linked
	mandatory mark not awarded
	benefit of doubt was considered, but the response was decided to not be sufficiently close for benefit of doubt to be applied.

Annotation	Meaning
POT	power of ten error
SEEN	point has been noted, but no credit has been given or blank page seen
SF	error in number of significant figures
TV	response is too vague or there is insufficient detail in response
	correct point or mark awarded
U	Incorrect unit
MO	method mark awarded
NAQ	question not answered
TE	transcription error

Mark Scheme Abbreviations:

;	separates marking points
/	alternative responses for the same marking point
R	reject the response
A	accept the response
I	ignore the response
ecf	error carried forward
AVP	any valid point
ora	or reverse argument
AW	alternative wording

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Question	Answer	Marks	Guidance
1(a)	horizontal line from (0, 8) to (6, 8)	B1	all points $\pm \frac{1}{2}$ small square throughout
	straight line from (0, 0) to (6, 18)	B1	labels not needed
1(b)	$(a =) v (-u) / t$ in any form algebraic or numerical	C1	A numerical values for cyclist or runner or $\pm \frac{1}{2}$ graph small square
	3(.0)	A1	ecf as always, here from an incorrect graph; accept –3 remember to round answer to 2 s.f., so e.g. A 2.95 but not 2.9;
	m / s^2	B1	ignore N / kg as the unit
1(c)	<i>working must be shown and final value calculated:</i>		expected values 40 (m) and 37.5 or 38 (m)
	(runner) 5×8 and 40	B1	cao correct answer only
	(cyclist = area under graph) $\frac{1}{2} \times 15 (\pm 0.5) \times 5$ and 37.5 or 38	B1	ecf from graph with ± 0.5 on y-axis for cyclist graph max 1 if no working, i.e. if only 40 and 37.5 or 38 seen or wrong units for distance clearly shown, e.g. m^2 ; m / s SC answers using 6 s as time (48 m and 54 m) 1 mark even with no working

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Question	Answer	Marks	Guidance
1(d)	simple statement of 1st law: an object/athlete remains at rest / uniform motion / constant motion / keeps moving unless a <u>force</u> acts	C1	ignore just ‘remains at rest’; $F=ma$ must mention the word ‘force’ A a force causes movement / motion / speed / velocity to change
	complete statement and correctly applied to athlete: athlete moves at constant velocity / constant speed (in a straight line) / uniform motion / zero acceleration unless acted upon by a net / resultant / unbalanced force OR constant velocity / speed in a constant direction / uniform motion / no acceleration means no resultant force on athlete	A1	look for • uniform motion / uniform speed etc ignore at rest • unless / no resultant / net / unbalanced force • applied correctly to athlete (e.g. mentions athlete’s constant speed or describes forces on athlete) I constant motion/remains at rest / external force in this mark

Question	Answer	Marks	Guidance
2(a)	(total) clockwise moment equals (total) anti-clockwise moment	M1	A CW = ACW or similar as long as <u>moment</u> is mentioned
	when the object is stationary / not turning / in equilibrium / balanced	A1	

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Question	Answer	Marks	Guidance
2(b)	(moment =) force $\times$ distance in any form algebraic or numerical	C1	ignore $F_1d_1 = F_2d_2$ algebraic equation A moment = F_1d_1 ; A any force (200 or 650) multiplied by any distance (0.4, 0.8 or 1.2) even in an $F_1d_1 = F_2d_2$ equation
	80 (Nm)	A1	
2(c)	(weight of student =) 40×9.8 or 392 (N) seen	C1	allow 10 for 9.8
	moment equation seen with $F_1d_1 = F_2d_2$ (+ 80)	C1	e.g. $650 \times 0.8 = 40 \times 9.8 \times d$ (+ value from (b)); e.g. $392d \geq 520$ A = or > in a moment equation
	1.1(2) m	A1	I distances greater than 1.12 m on answer line

Question	Answer	Marks	Guidance
3(a)(i)	At least 2 from - height / depth (of water) / quantity or amount of water in dam - density (of water / liquid) - acceleration of gravity / gravitational field strength - atmospheric pressure - force (on surface / inlet) - area (of surface / inlet)	B1	I thickness; area of dam
3(a)(ii)	at P – upwards / towards P at Q – downwards / towards Q	B1	I top, bottom; north, south both needed
3(b)	ANY one from geothermal, tidal, solar, wind, biomass, wave (energy)	B1	A sunlight; solar panels; solar cell; wind turbines; biogas ; solar power; wood from a managed source I just 'wood' not nuclear

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Question	Answer	Marks	Guidance
3(c)(i)	$(E =) P \times t$ in any form algebraic or numerical	C1	A $2.5 (\times 10^6) \times 30$; $2.5 \times 30 \times 60$; 4.5×10^n ; $P = W / t$
	4.5×10^9 (J)	A1	
3(c)(ii)	efficiency = (power) output / (power) input in any form	C1	A $0.95 = 2.5 / P_{IN}$; (useful) energy output / energy input e.g. $0.95 = \mathbf{3(c)(i)} / \text{input in any form}$
	2.6(3 MW)	A1	A 2.6×10^6 with unit MW only 1 mark

Question	Answer	Marks	Guidance
4(a)	amount of (thermal) energy / heat to cause:		answers must have mention of energy or heat energy over / per (unit) mass and temperature <u>change / rise</u> can have 1 mark, and with equation as long as symbols explained and mention of temperature <u>change</u> max 1 for major error, e.g. latent heat
	• unit rise in temperature or rise of $1^\circ\text{C} / 1\text{ K}$	B1	
	• temperature rise in unit mass / $1\text{ kg} / 1\text{ g}$	B1	
4(b)	$(E =) mc(\Delta)T$ in any form algebraic or numerical	C1	A ΔT values of 90°C and 75°C in a numerical response A algebraic forms that include T or θ rather than ΔT or $\Delta\theta$ expect $250 \times 4.2 \times 15$ do not accept t for T in formula but allow formula if t uses temperature readings even if c and Q are mistaken
	16 000 (J)	A1	15750 A –ve value

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Question	Answer	Marks	Guidance
4(c)(i)	(almost) no particles / atoms / molecules / matter / material (in vacuum)	B1	A 'very few' particles; particles reduced in number; no air / gas; vacuum is empty (space); (most energy transfer) requires a medium
	any one from: - conduction or convection are not possible - energy cannot pass from particle to particle by collision of particles (in conduction) from one particle to another - air / gas cannot rise / fall (in convection)	B1	I radiation; conduction does not occur in air; the word 'convection' if clearly just in the liquid A there is no conductor; no conducting path con no radiation; radiation not possible;
4(c)(ii)	(inner wall) white / silver and smooth / shiny	M1	A bright / reflective / glossy / silky for shiny not rough I outer walls treated for both marks; I 'grey'
	one explanation from: - less radiation (emitted / given off) - less radiation absorbed - poor emitter (of heat); good reflector (of heat) - poor absorber (of heat)	A1	A infra red / IR for radiation A reflects infra red / radiation (back to mug); no radiation given off; I reflects outside heat; just 'reflects heat' ie must be good reflector
4(d)	ANY 2 from: - hot <u>air</u> rises (and leaves the mug) / cold <u>air</u> sinks - hot air less dense (than cold air) <u>convection</u> (in air) or <u>evaporation</u> occurs - particles with most / more (thermal / kinetic) energy / speed escape/evaporate (from liquid) / less energetic / slower particles remain	B2	allow hot <u>air</u> particles rise i.e. must be clear air is rising I hot air <u>particles</u> less dense ; air is lighter convection / convect and / or evaporation / evaporate words needed I convection in water I 'hotter particles escape liquid' ; higher temperature particles escape A energetic particles for idea of more energy A water vapour / steam escapes / rises
5(a)(i)	correct normal	B1	by eye; either one side or the other of boundary or both

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Question	Answer	Marks	Guidance
5(a)(ii)	three correct refractions on entering and leaving the prisms	B1	I central block con dispersion, e.g. ray splits on refraction allow one wrong refraction of a ray at a boundary
	horizontal ray through and emerging from central glass block	B1	
5(a)(iii)	correct arrangement of prisms	B1	i.e. Intention that prisms inverted vertically, e.g. apex of prisms face central block
	rays diverge after prisms (top diverges up and bottom diverges down)	B1	I refraction in block and prisms; I ray leaving the block not if rays split on refraction; no prisms shown
5(b)	one correct ray; top ray passes through / to F on right of lens or bottom ray horizontal on right of lens	C1	
	both rays correct and image shown	A1	A point of intersection marked as I / image A arrow either way up as image at image position without a label
5(c)	ANY 2 from - wavelength decreases (towards the right) - frequency increases (towards the right) - damage / ionisation / energy increases (towards the right)	B2	A reverse arguments con speed changes assume left to right unless stated otherwise A just 'radio waves largest / large(r) λ '; ' γ small(est) λ ' 'gamma have high(est) / high(er) frequency'; 'radio low(est) frequency' SC allow 1 mark for <i>wavelength increases and freq. decreases</i> ; radio has largest λ and smallest frequency ORA for gamma

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Question	Answer	Marks	Guidance
6(a)	e.m.f. (work done on unit charge or voltage) in complete circuit or by the source / battery	B1	e.m.f: energy converted to electrical energy; p.d: electrical energy converted to other types
	p.d. (work done on unit charge or voltage) in / on a component / conductor / resistor / equipment / between two points	B1	not emf is a force ignore (work for) part / section of a circuit; force in p.d explanation i.e. do not accept 'force across a component'
6(b)(i)	resistance = voltage / current	B1	A $R = V/I$ in any form symbol or words
6(b)(ii)	same / equal	B1	
6(c)(i)	3.6 (V) seen	B1	
6(c)(ii)	(current =) 3.6 / 200 or 0.018 (A) seen	C1	ecf as usual but not for 6 / 200 A 6(c)(i) / 200 A potential divider calculation ($(R_{LDR} =) R_{FR} \times V_{LDR} / V_{FR}$ or numerical equivalent)
	130 Ω	A1	133.3
6(d)	1st two rows decreases and increases	B1	if 4th row is 'stay the same' then accept 5th row 'stay the same'
	2nd, 3rd and 4th rows same as each other	B1	
	5th row opposite of 4th row	B1	

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Question	Answer	Marks	Guidance
7(a)(i)	straight lines in 3 middle sections of the solenoid with no lines crossing / merging inside the whole of the solenoid	B1	at least two lines inside solenoid parallel to axis in middle section but may bend at ends
	lines fanning outwards at each end (and looping around solenoid)	B1	needs at least 2 lines at each end to show fanning outwards, complete loop not needed; may fan out from poles outside end of coil
	direction correct on at least 1 line and nowhere wrong	B1	i.e. into right end and out of left end and right to left inside solenoid
7(a)(ii)	lines closer together / more lines / denser	B1	A lines reach further out; just 'field lines increase'; I field lines become closer <u>to solenoid</u>
7(b)(i)	magnetic field cuts (coil) / magnetic field (in coil) changes	B1	A (magnetic) flux in coil changes; 'magnetic field is cut'; magnetic flux linkage <u>change</u> not field cuts field of coil; magnetic field cuts electric field
	<u>induction</u> occurs / voltage <u>induced</u> (in coil)	B1	A current induced
7(b)(ii)	ANY one from: • more turns / coils (on coil or solenoid) • use iron inside tube • lower resistance lamp / thicker wires in coil • increase voltage of <u>d.c. power supply</u> • increase current in or voltage to <u>solenoid</u> • move coil closer to solenoid	B1	I increased magnetic field strength; larger area of tube / coil / solenoid, move coil; add more solenoid A use large number of turns A extra batteries, increase dc supply

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Question	Answer	Marks	Guidance
7(b)(iii)	induced e.m.f. / induced current opposes the change producing it or mention of Lenz's law	B1	
	any one from: - like / same poles facing/opposite each other - like / same poles <u>on coil and solenoid</u> repel - field of solenoid opposed by/repelled by another field (from coil) - current in solenoid and current in coil oppose each other / in opposite directions	B1	not if charges mentioned for this mark A 'like / same poles on coil and solenoid repel' I just 'like / same poles repel'

Question	Answer	Marks	Guidance
8(a)	ANY two: (compared to gamma) beta particles are: - more ionising - lower range / less penetrating - more easily absorbed	B2	a comparison is needed between beta and gamma e.g. just 'beta is a strong ioniser' is not enough but 'beta stronger ioniser' is sufficient I comments on harm caused; moderate ioniser; stopped by Al; ionises more quickly; beta stopped by Al and gamma by lead; moderate penetration; references to alpha max 1 mark if reference made to different half lives both marks can be awarded in either 1 or 2 in the answer
8(b)(i)	Geiger–Müller (tube / detector)	B1	A GM (tube / detector) Geiger (tube / meter) I spark counter / cloud chamber
8(b)(ii)	emission is random	B1	A emission is in any direction; radioactivity is random; background is random I spontaneous
8(b)(iii)	10 (counts / min)	B1	
8(b)(iv)	80 / 2 or 40 seen	C1	A 90 / 2 or 45 and (90–8biii) / 2 and (90+10) / 2
	50	A1	ecf (iv) i.e. A 40 + 8(b)(iv)

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Question	Answer	Marks	Guidance
8(c)	Any one from: - patient is radioactive for shorter time (beta) particles emitted for shorter time - body contains I–131 for less time - radioactive isotopes removed quickly	B1	I just 'iodine–131 radioactive for shorter time; causes less / minimum harm; treatment takes less time; <u>beta / particles</u> decay faster; A it dissipates quicker; radiation stops sooner; decays fast(er)
8(d)	1 less neutron / mass 1 (u) less	B1	I nucleon number the same; number of electrons given
	1 more proton / charge 1 (e) more / atomic number increases by 1	B1	A neutron turns into a proton (and electron) for 2 marks allow values created by candidate that show these changes

Question	Answer	Marks	Guidance
9(a)	comet through X and Y, passing to the left side of the Sun and closest to Sun between Venus and Mercury	B1	I paths drawn to the right of X and Y; expect elliptical but accept other shapes, e.g. circular or with straight lines; allow the comet drawn to pass through outer Sun or planets

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Question	Answer	Marks	Guidance
9(b)	Any 2 from: • small(er) circumference / short(er) distance to travel (for an orbit) / small(er) orbit • great(er) <u>speed</u> / <u>velocity</u> / moves fast(er) • strong(er) gravitational field / gravitational force (of Sun) / attraction to Sun	B1	I closer to Sun; mercury has smaller mass; smaller orbital radius
		B1	assume circumference refers to the orbit rather than the planet unless otherwise stated I mention of energy; masses; radius of planet and orbit; orbits faster (could be time) A gravitational field affects mercury more
9(c)(i)	(nuclear) fusion	B1	not fission I fussion
9(c)(ii)	gravitational attraction inwards / gravitational force inwards / pulled inwards by gravity	B1	A 'pressure' for 'force' throughout I just 'due to gravity'
	balanced by or equal to an outwards force due to one of: • high temperature / fusion reactions / (thermal) expansion of Sun • pressure (in centre of Sun) radiation pressure	B1	A 'external' for 'outward' fusion e.g. H turns to He I ; 'nuclear force' A 'due to high energy / high amounts of heat' SC A outwards force = inwards force; forces balanced / cancel grav force and force from fusion equal; 1 mark if no other mark scored

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Question	Answer	Marks	Guidance
9(c)(iii)	becomes a red giant	B1	I mention of red supergiant or black dwarf; red giant explodes as this happens as the nebula is formed not if black hole / neutron star / supernova also formed at any stage
	ANY 2 from: • (outside of) Sun expands • (most of the) hydrogen has been used up • centre of star / core contracts / collapses / shrinks • other elements fuse together / heavier elements form • more energy / heat generated / temperature rises • (planetary) nebula emitted / layers of dust and gas emitted becomes a white dwarf (after the red giant)	B2	A all hydrogen has become helium I just 'hydrogen becomes less'; 'fuel runs out'. I just 'contracts' must be the core rather than the Sun collapsing A heavier elements formed even in a supernova A nebula after a supernova not if after a different stage, e.g. a protostar or a supernova