

GCE

Physics B

H557/01: Fundamentals of physics

A Level

Mark Scheme for June 2025

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This mark scheme is published as an aid to teachers and students, to indicate the requirements of the examination. It shows the basis on which marks were awarded by examiners. It does not indicate the details of the discussions which took place at an examiners' meeting before marking commenced.

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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MARKING INSTRUCTIONS

PREPARATION FOR MARKING RM ASSESSOR

1. Make sure that you have accessed and completed the relevant training packages for on-screen marking: *RM Assessor Online Training; OCR Essential Guide to Marking*.
2. Make sure that you have read and understood the mark scheme and the question paper for this unit. These are available in RM Assessor.
3. Log-in to RM Assessor and mark the **required number** of practice responses (“scripts”) and the **number of required** standardisation responses.

MARKING

1. Mark strictly to the mark scheme.
2. Marks awarded must relate directly to the marking criteria.
3. The schedule of dates is very important. It is essential that you meet the RM Assessor 50% and 100% (traditional 40% Batch 1 and 100% Batch 2) deadlines. If you experience problems, you must contact your Team Leader (Supervisor) without delay.
4. If you are in any doubt about applying the mark scheme, consult your Team Leader by telephone, email or via the RM Assessor messaging system.

5. **Crossed Out Responses**

Where a candidate has crossed out a response and provided a clear alternative then the crossed-out response is not marked. Where no alternative response has been provided, examiners may give candidates the benefit of the doubt and mark the crossed-out response where legible.

Rubric Error Responses – Optional Questions

Where candidates have a choice of question across a whole paper or a whole section and have provided more answers than required, then all responses are marked and the highest mark allowable within the rubric is given. Enter a mark for each question answered into RM Assessor, which will select the highest mark from those awarded. *(The underlying assumption is that the candidate has penalised themselves by attempting more questions than necessary in the time allowed.)*

Multiple-Choice Question Responses

When a multiple-choice question has only a single, correct response and a candidate provides two responses (even if one of these responses is correct), then no mark should be awarded (as it is not possible to determine which was the first response selected by the candidate).

When a question requires candidates to select more than one option/multiple options, then local marking arrangements need to ensure consistency of approach.

Contradictory Responses

When a candidate provides contradictory responses, then no mark should be awarded, even if one of the answers is correct.

Short Answer Questions (requiring only a list by way of a response, usually worth only one mark per response)

Where candidates are required to provide a set number of short answer responses then only the set number of responses should be marked. The response space should be marked from left to right on each line and then line by line until the required number of responses have been considered. The remaining responses should not then be marked. Examiners will have to apply judgement as to whether a 'second response' on a line is a development of the 'first response', rather than a separate, discrete response. *(The underlying assumption is that the candidate is attempting to hedge their bets and therefore getting undue benefit rather than engaging with the question and giving the most relevant/correct responses.)*

Short Answer Questions (requiring a more developed response, worth two or more marks)

If the candidates are required to provide a description of, say, three items or factors and four items or factors are provided, then mark on a similar basis – that is downwards (as it is unlikely in this situation that a candidate will provide more than one response in each section of the response space.)

Longer Answer Questions (requiring a developed response)

Where candidates have provided two (or more) responses to a medium or high tariff question which only required a single (developed) response and not crossed out the first response, then only the first response should be marked. Examiners will need to apply professional judgement as to whether the second (or a subsequent) response is a 'new start' or simply a poorly expressed continuation of the first response.

6. Always check the pages (and additional objects if present) at the end of the response in case any answers have been continued there. If the candidate has continued an answer there, then add the annotation 'SEEN' to confirm that the work has been seen and mark any responses using the annotations in section 11.
7. There is a NR (**No Response**) option. Award NR (No Response):
 - if there is nothing written at all in the answer space
 - OR if there is a comment which does not in any way relate to the question (e.g., 'can't do', 'don't know')

- OR if there is a mark (e.g., a dash, a question mark) which is not an attempt at the question.

Note: Award 0 marks – for an attempt that earns no credit (including copying out the question).

8. The RM Assessor **comments box** is used by your team leader to explain the marking of the practice responses. Please refer to these comments when checking your practice responses. **Do not use the comments box for any other reason.**
9. *Assistant Examiners will send a brief report on the performance of candidates to their Team Leader (Supervisor) via email by the end of the marking period. The report should contain notes on particular strengths displayed as well as common errors or weaknesses. Constructive criticism of the question paper/mark scheme is also appreciated.*
10. For answers marked by levels of response:
 - a. **To determine the level** – start at the highest level and work down until you reach the level that matches the answer
 - b. **To determine the mark within the level**, consider the following

Descriptor	Award mark
On the borderline of this level and the one below	At bottom of level
Just enough achievement on balance for this level	Above bottom and either below middle or at middle of level (depending on number of marks available)
Meets the criteria but with some slight inconsistency	Above middle and either below top of level or at middle of level (depending on number of marks available)
Consistently meets the criteria for this level	At top of level

11. Annotations

Annotation		Meaning
	Correct response	Used to indicate the point at which a mark has been awarded (one tick per mark awarded).
	Incorrect response	Used to indicate an incorrect answer or a point where a mark is lost.
AE	Arithmetic error	Do not allow the mark where the error occurs. Then follow through the working/calculation giving full subsequent ECF if there are no further errors.
BOD	Benefit of doubt given	Used to indicate a mark awarded where the candidate provides an answer that is not totally satisfactory, but the examiner feels that sufficient work has been done.
BP	Blank page	Use BP on additional page(s) to show that there is no additional work provided by the candidates.
CON	Contradiction	No mark can be awarded if the candidate contradicts himself or herself in the same response.
ECF	Error carried forward	Used in <u>numerical answers only</u> , unless specified otherwise in the mark scheme. Answers to later sections of numerical questions may be awarded up to full credit provided they are consistent with earlier incorrect answers. Within a question, ECF can be given for AE, TE and POT errors but not for XP.
L1	Level 1	L1 is used to show 2 marks awarded and L1^ is used to show 1 mark awarded.
L2	Level 2	L2 is used to show 4 marks awarded and L2^ is used to show 3 marks awarded.
L3	Level 3	L3 is used to show 6 marks awarded and L3^ is used to show 5 marks awarded.
POT	Power of 10 error	This is usually linked to conversion of SI prefixes. Do not allow the mark where the error occurs. Then follow through the working/calculation giving ECF for subsequent marks if there are no further errors.

Annotation		Meaning
SEEN	Seen	To indicate working/text has been seen by the examiner.
SF	Error in number of significant figures	Where more SFs are given than is justified by the question, do not penalise. Fewer significant figures than necessary will be considered within the mark scheme. Penalised only once in the paper.
TE	Transcription error	This error is when there is incorrect transcription of the correct data from the question, graphical read-off, formulae booklet or a previous answer. Do not allow the relevant mark and then follow through the working giving ECF for subsequent marks.
XP	Wrong physics or equation	Used in <u>numerical answers only</u> , unless otherwise specified in the mark scheme. Use of an incorrect equation is wrong physics even if it happens to lead to the correct answer.
^	Omission	Used to indicate where more is needed for a mark to be awarded (what is written is not wrong but not enough).

Annotation	Meaning
/	Alternative and acceptable answers for the same marking point
✓	Separates marking points
Not	Answers which are not worthy of credit
Ignore	Statements which are irrelevant
Allow	Answers that can be accepted
()	Words which are not essential to gain credit
—	Underlined words must be present in answer to score a mark
ECF	Error carried forward
AW	Alternative wording
ORA	Or reverse argument

12. Subject Specific Marking Instructions

INTRODUCTION

Your first task as an Examiner is to become thoroughly familiar with the material on which the examination depends. This material includes:

- the specification, especially the assessment objectives
- the question paper
- the mark scheme.

You should ensure that you have copies of these materials.

You should ensure also that you are familiar with the administrative procedures related to the marking process.

Please ask for help or guidance whenever you need it. Your first point of contact is your Team Leader.

Significant figure penalties

Significant figure penalties will be shown on the mark scheme. There is a maximum of one significant figure penalty on each paper. Not all papers will include such penalties – this depends on the particular questions given in the paper. The question that attracts a significant figure penalty (if one do so) will be decided by the examiners at the standardisation meeting. You must not penalize such errors unless clearly stated in the mark scheme.

Annotation on scripts

Each markworthy point should be registered with a tick – the total number of ticks on the paper should equal the number of marks awarded for non-LOR questions. Mark errors in physics with a cross and omissions with a carat. Centres and candidates who request scripts back find such annotations extremely useful.

LOR questions do NOT have ticks on the papers. These questions should only be annotated with L1, L2, L3.

Question			Answer	Marks	Guidance
1			D	1	
2			B	1	
3			B	1	
4			C	1	
5			D	1	
6			A	1	
7			B	1	
8			B	1	
9			C	1	
10			B	1	
11			B	1	
12			A	1	
13			B	1	
14			D	1	
15			D	1	
16			C	1	
17			A	1	
18			C	1	
19			D	1	
20			B	1	
21			C	1	
22			A	1	
23			D	1	
24			B	1	
25			B	1	
26			B	1	
27			C	1	
28			A	1	
29			B	1	
30			A	1	
			Total	30	

Question			Answer	Mark	Guidance
31	(a)	(i)	Use of $(v = u + at)$ 9.81×1.5 ✓ = $14.7 \text{ (ms}^{-1}\text{)}$ ✓	1 1	Allow $15 \text{ (ms}^{-1}\text{)}$ Bald correct answer gains all marks
	(a)	(ii)	Horizontal vector = $4.0 \text{ cm} \pm \frac{1}{2}$ small square and vertical vector = $7.4 \text{ cm} \pm \frac{1}{2}$ small square ✓ Speed = $16.7 \pm 0.2 \text{ (ms}^{-1}\text{)}$ ✓	1 1	Must have arrows tip to tail and in correct direction Allow ECF from (i) Answer must be read off a scale diagram and not from any other methods
	(b)		2 marks maximum for correct calculations: When horizontal distance = 20 m , $t (=20/8) = 2.5 \text{ s}$ ✓ Then vertical distance $(= \frac{1}{2} \times 9.81 \times 2.5^2) = 30.6 \text{ m}$ ✓ When the parachutist is 80 m above the ground distance fallen = 70 m and $t (= \sqrt{2 \times 70/9.81}) = 3.78 \text{ s}$ ✓ Then horizontal distance $(= 8 \times 3.78) = 30.24 \text{ m}$ ✓ 1 mark for a valid conclusion based on calculations: Conclusion – when the parachutist is 20 m from the cliff he is 119 m above the ground so he can avoid injury ✓ Conclusion – when the parachutist is 80 m from the ground he is 30.2 m from the cliff so he can avoid injury ✓ Conclusion – when the time taken to fall is larger than the time taken to get 20 m he would avoid injury so $3.78 \text{ s} > 2.5 \text{ s}$	1 1 1	Allow 3.77 s Allow conclusion based on correct physics but with arithmetical error(s) in calculation

Question			Answer	Mark	Guidance
32	(a)		$Q = CV$ substituted into $E = \frac{1}{2}QV$ ✓	1	
	(b)		When $E = 12$ mJ, $V = \sqrt{(2 \times 12 \times 10^{-3}) / (6.8 \times 10^{-4})}$ $= 5.94$ V ✓ When $E = 4$ mJ, $V = \sqrt{(2 \times 4 \times 10^{-3}) / (6.8 \times 10^{-4})}$ $= 3.43$ V ✓ $t = -\ln(3.43/5.94) \times 1.2 \times 10^3 \times 6.8 \times 10^{-4}$ ✓ $= 0.45$ s ✓	1 1 1 1	Other routes may be used. $\ln(V_0/V) = \ln(\sqrt{12/4})$ gains first 2 marks Bald correct answer gains all marks
33			1st mark The distance of the planet at the time of each pulse $= \text{speed of light} \times \text{journey time} \div 2$ ✓ OR Correct calculation of a distance: 1st distance $= 3.0 \times 10^8 \times 12.000014/2$ ($= 1.8000021 \times 10^9$ m) or 2nd distance $= 3.0 \times 10^8 \times 12/2$ ($= 1.8000 \times 10^9$ m) ✓ 2nd mark velocity $= \text{difference between two values} \div \text{time between pulses}$ ✓ OR Calculation of velocity: velocity $= (1^{\text{st}} \text{ distance} - 2^{\text{nd}} \text{ distance}) / 900$ $(= 2100 \text{ m}) / 900 \text{ s}$ ✓	1 1	Not A correct value of velocity with no clear working.

Question			Answer	Mark	Guidance
34	(a)	(i)	Substitute into equation – $a = (100000 \times 0.05 - 240)/1200 (= 3.97 \text{ m s}^{-2}) \checkmark$	1	
	(a)	(ii)	Use of $s = ut + \frac{1}{2}at^2 \checkmark$ $= 0 + \frac{1}{2} \times 3.97 \times 0.02^2$ OR $0.000794 \text{ m} \checkmark$	1 1	Allow method using $x = A \cos(\omega t)$ ECF from ai
	(a)	(iii)	Displacement $(= 0.050 - 0.000794) = 0.0492 \text{ m} \checkmark$	1	
	(b)	(i)	From graph T when $x = 0 = 0.173 \text{ (s)} \checkmark$ $T = 0.173 \times 4 = 0.69 \text{ (s)} \checkmark$	1 1	Allow x to be in range of 0.172 to 0.173 Bald correct answer gains all marks
	(b)	(ii)	$f = \sqrt{[3.97 \div (4\pi^2 \times 0.050)]} (= 1.42) \checkmark$ $T = (1 \div 1.42) = 0.705 \text{ (s)} \checkmark$	1 1	 Bald correct answer gains all marks
	(b)	(iii)	Use steps smaller (than 0.02 s)	1	Allow alternative wording NOT more frequent readings

Question			Answer	Mark	Guidance
35	(a)		1200 MeV = 1.92×10^{-10} J ✓	1	Bald correct answer gains all marks
			$1.92 \times 10^{-10} = 5.0 \times 10^{-4} \times 0.1 \times \Delta\theta$ ✓	1	
			$\Delta\theta = 3.84 \times 10^{-6}$ K ✓	1	
	(b)		The detector is more sensitive / gives a large increase in temperature at lower temperature (because the specific thermal capacity is lower) ✓	1	Allow converse argument

Question			Answer	Mark	Guidance
36	(a)	(i)	Speed of light is slower in the glass / faster in air / slows as it crosses the boundary ✓	1	
	(a)	(ii)	$n = c\Delta t \div c_g \Delta t = DB \div CA$ OR $\sin i \div \sin r = DB \div CA$ ✓ $n = 4.5 \div 3.0 = 1.5$ ✓	1 1	Must see DB, CA OR CB for first mark
	(b)	(i)*	Level 3 (5–6 marks) Covers all strands fully and accurately. <i>There is a well-developed line of reasoning which is clear and logically structured. The information presented is relevant and substantiated.</i> Level 2 (3–4 marks) Covers all strands with some small inaccuracies OR covers 2 strands accurately. <i>There is a line of reasoning presented with some structure. The information presented is in the most-part relevant and supported by some evidence.</i> Level 1 (1–2 marks) Covers 2 strands with some inaccuracies OR covers 1 strand accurately. <i>The information is basic and communicated in an unstructured way. The information is supported by limited evidence and the relationship to the evidence may not be clear.</i>	6	Indicative scientific points may include: Identifying lines of best and worst fit Drawing the line of best fit. Drawing the steepest line of best fit must pass through all error bars Drawing the shallowest line of best fit must pass through all error bars Lines do not have to pass through the origin. Finding gradients Finding the gradients of each line using points at least half the drawn line apart. Line of best fit gradient 1.54 ± 0.02 Steepest fit line of best fit 1.88 ± 0.02 Shallowest fit line of best fit 1.30 ± 0.02 Analysis / Conclusion Using the gradients of the worst lines and that of the best line to estimate the uncertainty in the value of n. 1.6 ± 0.3 Statement on whether the block could be crown or flint glass consistent with gradients.

Question			Answer	Mark	Guidance
			0 marks No response or no response worthy of credit		

Question			Answer	Mark	Guidance
37	(a)	(i)	Straight line from P passing through equipotentials at right angles, ✓	1	Must be drawn with a ruler and no hairy lines
			Arrow pointing towards Bennu ✓	1	
	(a)	(ii)	In going from R to Q it requires an increase potential energy ✓ To do this requires a decrease in kinetic energy (hence a thrust is needed to slow the craft down) ✓ OR If no input of kinetic energy stay on the same equipotential line ✓ Height is reduced as approach Q. ✓	1 1	AW
	(b)	(i)	Attempt at drawing tangent at 600m. ✓ Drawn accurately at one point of contact (by eye). ✓ Two points (at least half the length of the tangent apart) used in the calculation $a = \frac{E_2 - E_1}{d_2 - d_1}$ ✓ Value for force in the range 0.0106 N to 0.0110 N ✓	1 1 1 1	
	(b)	(ii)	E_k (needed by spacecraft $\frac{1}{2} \times 2000 \times v^2$) = 13 ± 0.2 (from graph) ✓ $v = \sqrt{[(2 \times \text{read off of graph})/2000]}$ ✓ = 0.114 ms^{-1} ✓	1 1 1	Values in range of 0.1131 to 0.1149

Question			Answer	Mark	Guidance
38	(a)		Use of $V_p/V_s = N_p/N_s$ ✓	1	24 V scores 3 marks 0.025 A scores 2 marks
			$V_p = 400/50 \times 3$ ✓	1	
			$= 24 \text{ V}$ ✓	1	
			$24 \times I_p = 0.6$ OR $I_p = 50/400 \times 0.2$ ✓	1	
			$I_p = (0.6/24) = 0.025 \text{ A}$ ✓	1	
	(b)		Any three from: - Changing flux induces e.m.f.s - Which drive eddy currents - Layers of insulator reduce the (eddy) currents - Less energy is dissipated in the core (as thermal energy) ✓✓✓	1 1 1	Allow candidates to consider the interaction between the field induced by the eddy currents and the flux through the coil, and then cite Lenz's Law. Allow reduces heat loss for 4 th bullet point
	(c)		Air has a (much) lower permeability than iron ✓ (Component of) flux density (perpendicular to coil turns) reduced ✓ So <u>rate of change</u> of magnetic flux through the secondary coil is reduced ✓	1 1 1	Allow air has a greater reluctance than iron.

Question			Answer	Mark	Guidance																				
39	(a)		Rotate R in a vertical plane through (at least) 90° perpendicular to the path of the microwaves ✓ Where maximum occurs identification of this as plane. ✓	1 1	Allow AW ORA																				
	(b)	(i)	First order maximum is 16 cm from B ✓ Angle of first order maximum = $\tan^{-1}(16/60)$ = 14.9° ✓ $\sin(14.9^\circ) = 1 \times \lambda / 12$ ✓ ($\lambda = \sin(14.9^\circ) \times 12 = 3.1$ cm)	1 1 1	Allow 15 cm for 1 st order max Allow method using $\lambda=ax/D$ Allow 35 cm and 34 cm for 2 nd order max <table><tr><th>n</th><th>x / cm</th><th>$\tan^{-1} \theta$</th><th>λ /cm $12 \sin(\theta) \div n$</th></tr><tr><td>$n = 1$</td><td>16</td><td>$\tan^{-1} \theta = 14.9^\circ$</td><td>3.1</td></tr><tr><td>$n = 1$</td><td>15</td><td>$\tan^{-1} \theta = 14.0^\circ$</td><td>2.9</td></tr><tr><td>$n = 2$</td><td>35</td><td>$\tan^{-1} \theta = 30.2^\circ$</td><td>3.0</td></tr><tr><td>$n = 2$</td><td>34</td><td>$\tan^{-1} \theta = 29.5^\circ$</td><td>3.0</td></tr></table>	n	x / cm	$\tan^{-1} \theta$	λ /cm $12 \sin(\theta) \div n$	$n = 1$	16	$\tan^{-1} \theta = 14.9^\circ$	3.1	$n = 1$	15	$\tan^{-1} \theta = 14.0^\circ$	2.9	$n = 2$	35	$\tan^{-1} \theta = 30.2^\circ$	3.0	$n = 2$	34	$\tan^{-1} \theta = 29.5^\circ$	3.0
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Question			Answer	Mark	Guidance
	(b)*	(ii)*	(Level 3) (5 – 6 marks) The formation of the maxima and minima is clearly explained using the wave model and/or the photon model. The decreasing size of the maxima moving out from the centre is addressed. <i>There is a well-developed line of reasoning which is clear and logically structured. The information presented is relevant and substantiated.</i> (Level 2) (3 – 4 marks) The formation of a maximum or a minimum is explained using the wave model and/or the photon model. The decreasing size of the maxima moving out from the centre is mentioned (but not necessarily explained). <i>There is a line of reasoning presented with some structure. The information presented is relevant and supported by some evidence.</i> (Level 1) (1 – 2 marks) The formation of a maximum or a minimum is addressed but not fully explained. <i>There is an attempt at a logical structure with a line of reasoning. The information is in the most part relevant</i> (0 marks) Insufficient or irrelevant science. Answer not worthy of credit.	6	The wave model • The light from the two slits is coherent (the waves have a fixed phase difference) • Waves passing through the slits diffract • And overlap / superpose • At a minimum the path difference between the waves from the two slits is $(n + \frac{1}{2})\lambda$ • At a minimum the waves from S_1 and S_2 are in antiphase (180° or π radians out of phase)/ destructive interference occurs • At a maximum the path difference between the waves from the two slits is $n\lambda$ • At a maximum the waves are in phase/ constructive interference occurs The photon model • All of the possible pathways between the slits and points of maxima or minima have to be taken into account/ photons explore all possible paths • Each photon has its own phasor arrow • The probability of a photon arriving at R a point is determined by combining phasors for all possible paths • Probability of a photon arriving is proportional to the square of the length of the resultant phasor arrow • Intensity at a point is proportional to the probability of a photon arriving at that point • The probability of a photon arriving at a point where the path difference = $(2n - 1)\lambda/2$ or $(n + \frac{1}{2})\lambda$ is low • The probability of a photon arriving at where the path difference = $n\lambda$ is high

Question			Answer	Mark	Guidance
					Decreasing size of maxima • Intensity decreases with $1/r^2$. • For increasing diffraction angles there will be an increasing path/phase difference between waves from different parts of the same slit. • Intensity at a point is proportional to the probability of a photon arriving at that point • As phasors move away from the central maximum the amplitude will decrease resulting in a decreasing intensity.

Question			Answer	Mark	Guidance
40	(a)	(i)	$eV = \frac{1}{2}mv^2$ and $Bev = mv^2/r$ ✓ $v^2 = 2eV/m$ and $v^2 = (Ber/m)^2$ and then eliminate v^2 ✓	1 1	Allow $qV = \frac{1}{2}mv^2$ and $Bqv = mv^2/r$ Allow alternative methods of algebra using equations from marking point 1
		(ii)	$r = (10^2 + 2^2)/(2 \times 2) = 26 \text{ cm} (= 0.26 \text{ m})$ ✓ $e/m = (2 \times 2000)/((5.80 \times 10^{-4})^2 \times 0.26^2)$ ✓ $= 1.76 \times 10^{11} \text{ (Ckg}^{-1}\text{)}$ ✓	1 1 1	Not $1.756 \times 10^{11} \text{ (Ckg}^{-1}\text{)}$
	(b)	(i)	When falling $8.3 \times 10^{-4} = (2 \times 920 \times 9.81 \times r^2)/(9 \times 1.8 \times 10^{-5})$ ✓ $r = 2.729 \times 10^{-6} \text{ m}$ ✓ $m = 4/3 \times \pi \times (2.729 \times 10^{-6})^3 \times 920 (= 7.83 \times 10^{-14} \text{ (kg)})$ ✓	1 1 1	2.73 gives 7.84
	(b)	(ii)	When stationary $Vq/d = mg$ ✓ $1.60 \times 10^4 \times q / 0.01 = 7.83 \times 10^{-14} \times 9.81$ ✓ $q = 4.80 \times 10^{-19} \text{ (C)}$ ✓	1 1 1	Allow ecf for m Allow $m = 7.8 \times 10^{-14} \text{ (kg)}$ ($q = 4.78 \times 10^{-19} \text{ C}$) $m = 7.84 \times 10^{-14} \text{ (kg)}$ ($q = 4.81 \times 10^{-19} \text{ C}$) Bald correct answer gains all marks

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