



NEW ZEALAND QUALIFICATIONS AUTHORITY
MANA TOHU MĀTAURANGA O AOTEAROA

Level 2, 2004

Physics

**Demonstrate understanding
of wave phenomena (90254)**

**Demonstrate understanding
of mechanics (90255)**

**Demonstrate understanding of
atoms and radioactivity (90256)**

**Demonstrate understanding of electricity
and electromagnetism (90257)**

National Statistics

Assessment Report

Assessment Schedule

Physics, Level 2, 2004

General Comments

Candidates gaining Achievement demonstrated their understanding of standards by stating key ideas and solving single-step problems correctly.

Successful candidates read, understood and acted upon key words in the questions that indicated what they were required to state or to calculate. They were able to apply their knowledge of physics to the particular situation presented in the questions.

Achievement was gained by candidates who gave evidence of their understanding of a number of different concepts within the content of the standard.

Unsuccessful candidates were unable to demonstrate that they understood the physics concepts contained in the standard, and often failed to attempt some or all of the questions.

Candidates who gained Achievement with Merit or Achievement with Excellence, wrote clear, concise and relevant explanations, often linking concepts. Their quantitative work was neatly set out and their mathematical processes were performed accurately.

Physics: Demonstrate understanding of wave phenomena (90254)

National Statistics

Number of Results	Percentage			
	Not Achieved	Achieved	Merit	Excellence
10,075	33.7%	47.8%	16.2%	2.3%

Assessment Report

Candidates who gained Achievement understood the necessity to demonstrate their understanding of a number of different wave phenomena. They were able to respond correctly to the key words of varied questions, both descriptive and numerical. Most candidates understood and followed the requirements of the questions.

Unsuccessful candidates had difficulty interpreting the questions. Their responses lacked substance, their answers did not relate well to the question, or they misunderstood the language of physics.

Candidates gaining Achievement were able to recall basic facts relating to wave phenomena and could draw diagrams, including ray diagrams. They could select and apply formulae and they were able to express their answers to questions requiring a statement or description.

Candidates assessed as Not Achieved, had difficulty interpreting questions because their basic knowledge of the wave topic was insufficient.

Successful candidates presented evidence of their understanding of wave phenomena by expressing their ideas clearly and by setting out all the working to their answers for numerical problems in a logical, easily followed manner. Solutions that required a “show” response indicated the steps of the calculation particularly clearly. Their diagrams were drawn carefully and confidently.

Candidates assessed as Not Achieved were unable to show that they understood the concepts, as their answers were unrelated to questions. Diagrams were drawn erratically, wrong choices of formulae were made, and the presentation of numerical solutions was messy. Many candidates did not complete enough of the paper.

Candidates who gained Achievement with Merit or Achievement with Excellence, were confident that they understood what a question was asking. Their responses to questions requiring an explanation were clear and succinct with minimal irrelevancies. “Excellence” candidates showed their ability to link different ideas. Qualitative answers to multi-step problems demonstrated mastery of processes.

Overall, candidates’ scripts showed that they were generally adept at solving most numerical problems correctly. In many cases, this proficiency was not matched with an equal facility to explain wave phenomena clearly. This implied that such candidates lacked true understanding of the concepts in this standard.

Physics: Demonstrate understanding of mechanics (90255)

National Statistics

Number of Results	Percentage			
	Not Achieved	Achieved	Merit	Excellence
10,308	46.7%	33.3%	15.1%	4.9%

Assessment Report

Candidates gaining Achievement recognised that they needed to demonstrate their understanding of mechanics by stating key ideas and solving single-step calculations correctly. They understood key words that indicated what they were required to state or calculate in order to answer all the questions in the paper.

Candidates assessed as Not Achieved did not understand the physics concepts involved and many did not attempt some sections of the paper. They were unable to answer questions as asked and could not draw vectors nor solve problems correctly.

Candidates who gained Achievement were able to draw vector diagrams, give considered responses to descriptive questions and solve problems.

Successful candidates presented evidence effectively and appropriately by drawing their diagrams with care, by writing clear and relevant responses to descriptive questions, and by setting out answers to quantitative questions neatly, logically and showing all working.

Candidates who gained Achievement with Merit or Achievement with Excellence, were able to explain underlying physics concepts clearly, succinctly and correctly, by writing explanations that showed true understanding, by keeping to the point and avoiding repetition, by using linking words, and by explaining the physics rather than the mathematics involved. Such candidates were also able to use manipulation in calculations, by synthesising two relationships and by understanding more complex concepts such as the *change* in a vector quantity.

The large number of candidates who made no attempt to answer Questions Two to Four was of concern. This resulted in a high proportion of candidates not achieving. Most questions included some easily-answered sections, so it is always worthwhile for candidates to make an honest attempt at every question.

Poorly-understood concepts in mechanics include conservation of energy, *change* in a vector quantity, forces (in general), where forces act on an object (in particular), significant figures, and the necessity for precision in the use of language in physics.

Physics: Demonstrate understanding of atoms and radioactivity (90256)

National Statistics

Number of Results	Percentage			
	Not Achieved	Achieved	Merit	Excellence
9,955	33.1%	44.4%	10.2%	12.3%

Assessment Report

Candidates gaining Achievement understood key words that required them to demonstrate their understanding of atoms and radioactivity. They recognised the phenomena described in the questions.

Candidates assessed as Not Achieved did not understand the basic concepts or terminology of the standard.

Candidates who gained Achievement used their skills and knowledge to complete nuclear equations, to explain radioactivity phenomena and to interpret the results of experiments.

Non-achieving candidates were unable to understand the significance of experiments, had little knowledge of radioactive decay and the nature of atoms.

Successful Achievement candidates presented evidence effectively and appropriately by using correct symbols and calculating correct values for nuclear equations and radiation. They were able to convey their understanding of physics concepts in well written answers.

Unsuccessful candidates used incorrect symbols and were unable to answer qualitative questions as asked.

Candidates who gained Achievement with Merit or Achievement with Excellence, were able to perform accurate calculations and use correct symbols and terminology. They had a clear understanding of atoms, nuclei and radioactive decay. They had the ability to demonstrate an understanding of half-life and to do quantitative work on carbon dating.

Physics: Demonstrate understanding of electricity and electromagnetism (90257)

National Statistics

Number of Results	Percentage			
	Not Achieved	Achieved	Merit	Excellence
10,277	39.6%	24.9%	26.0%	9.5%

Assessment Report

Candidates gaining Achievement understood the key words of the standard. They had a clear understanding of questions that related to single concepts.

Candidates gaining Achievement used their skills and knowledge to solve basic numerical problems well, including substitution, manipulation, calculation, significant figures and SI units. These candidates were able to describe phenomena in a satisfactory manner.

Candidates who achieved presented evidence effectively and appropriately by setting out their numerical answers well and showing clear working. Their explanations were concise and showed a good understanding of vocabulary.

Candidates assessed as Not Achieved misunderstood the concepts of electromagnetism.

Unsuccessful candidates were unable to answer qualitative questions, often merely repeating the question or being too verbose. They were unable to distinguish between the concepts of magnetic and electric fields.

Candidates who did not achieve failed to show that they could handle powers of 10 or conversion of units. They lacked the evidence to show correct selection of data. Explanations were often inadequate and contained evidence of contradiction.

Candidates who gained Achievement with Merit or Achievement with Excellence, showed good knowledge of electromagnetic induction and the concomitant rules relating to direction. They were able to synthesise two relationships and manipulate data correctly to solve problems. Their written explanations were more concise and they showed that they could link two separate scientific concepts.

In general, candidates' scripts showed that they achieved well when solving most numerical problems. In many cases, this success was not matched with an ability to explain electricity and electromagnetism concepts clearly. A large number of candidates did not achieve because they did not attempt some questions, and left a page or a number of pages blank.

Assessment Schedule

Physics: Demonstrate understanding of wave phenomena (90254)

Evidence Statement

Note: Minor computational errors will not be penalised. A wrong answer will be accepted as correct provided that there is sufficient evidence that the mistake is not due to a lack of understanding of the concepts in physics.

Such evidence could include the following:

- The last written step before the answer is given has no unexpanded brackets or terms and does not require rearranging.
- The power of any number that is multiplied by a power of 10 is correct.
- Numerical data were wrongly transferred but used correctly.

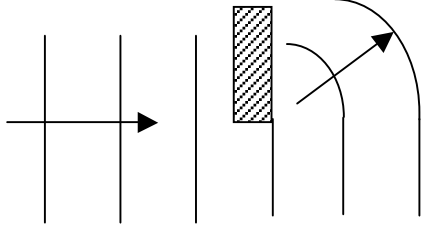
Correct units and significant figures are required only in the questions that specifically ask for them.

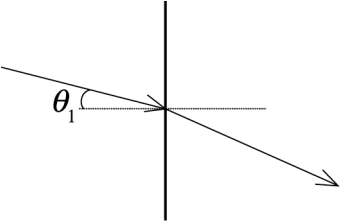
Italics indicate replacement evidence.

Question	Evidence	Evidence contributing to Achievement	Evidence contributing to Achievement with Merit	Evidence contributing to Achievement with Excellence
1(a)	Concave	¹ Correct answer.		
1(b)	<ul style="list-style-type: none"> • Ray parallel to axis is reflected back through the focus. • Ray directed at pole is reflected back at an equal angle. • Ray from centre of curvature reflected directly back through centre. • Ray from focus reflects from mirror parallel to principal axis. • Both rays are produced backwards, using dotted construction, to produce an upright and magnified image behind the mirror. 	¹ <i>Must show working towards a virtual image</i> <ul style="list-style-type: none"> • Any 2 correctly drawn construction lines showing reflection. 	¹ Achieved <i>plus rays</i> are produced behind the mirror and a correct image is drawn.	
1(c)	The image is virtual.	¹ Correct answer (ignore orientation or magnification).		

Question	Evidence	Evidence contributing to Achievement	Evidence contributing to Achievement with Merit	Evidence contributing to Achievement with Excellence
1(d)	$\frac{1}{f} = \frac{1}{d_o} + \frac{1}{d_i}$ $\frac{1}{4} = \frac{1}{2.5} + \frac{1}{d_i} \Rightarrow \frac{1}{d_i} = \frac{1}{4} - \frac{1}{2.5}$ $\frac{1}{d_i} = \frac{2.5 - 4.0}{4.0 \times 2.5} = \frac{-1.5}{10}$ $d_i = -\frac{10}{1.5} = -\frac{20}{3}$ $s_o s_i = f^2$ $s_i(1.5) = 16$ $s_i = \frac{16}{1.5} = 10.7$ $d_i = 10.7 - 4.0 = -6.7 \text{ cm}$	² Correct substitution.	² Achieved <i>plus</i> correct working.	
1(e)	$m = \frac{d_i}{d_o} = \frac{6.7}{2.5} = 2.7$	² Correct answer.		
1(f)	$m = \frac{h_i}{h_o}$ $h_o = \frac{h_i}{m} = \frac{2.0}{2.7} = 0.75 \text{ cm}$ or 0.74 cm $\frac{d_i}{d_o} = \frac{h_i}{h_o} \Rightarrow \frac{6.7}{2.5} = \frac{2.0}{h_o}$ $\Rightarrow h_o = \frac{2.5 \times 2.0}{6.7} = 0.75 \text{ cm}$	² Correct answer (accept answer that is consequentially correct from 1(e)).		

Question	Evidence	Evidence contributing to Achievement	Evidence contributing to Achievement with Merit	Evidence contributing to Achievement with Excellence
1(g)	$f = 4.0 \text{ cm}$ $d_o + d_i = 25 \text{ cm}$ $d_o = 25 - d_i$ $\frac{1}{4} = \frac{1}{25-d_i} + \frac{1}{d_i}$ $\frac{1}{4} = \frac{d_i + 25 - d_i}{(25-d_i) \times d_i}$ $\frac{1}{4} = \frac{25}{25d_i - d_i^2}$ $100 = 25d_i - d_i^2$ $d_i^2 - 25d_i + 100 = 0$ $(d_i - 5)(d_i - 20) = 0$ $d = 20 \text{ cm}$	² <i>Recognition that</i> <ul style="list-style-type: none"> $d_o + d_i = 25$ $s_o + s_i + 8 = 25$ <ul style="list-style-type: none"> 20 cm (no supported evidence or correct working). 	² <i>Achieved plus correct substitution and 1 correct step of working.</i>	² <i>Merit plus correct answer.</i> <ul style="list-style-type: none"> $d_i = 20 \text{ cm}$ (Note: both answers may be given but correct answer indicated.)
2(a)	Along a nodal line, travelling waves from each source completely cancel out the other due to their phase difference of 180° or $\lambda/2$ exactly out of phase. Waves or crests from one source of waves coincide with troughs from the other source of waves at a particular point on the nodal line. These disturbances destructively interfere or cancel out so that the water is flat.	¹ <i>Either statement of</i> <ul style="list-style-type: none"> destructive interference. Crest meets trough. 	¹ <i>Achieved plus explanation that at a node a crest and a trough superimpose causing destructive interference.</i>	¹ <i>Explanation that a Nodal line is a where an exact phase difference of 180° or $\lambda/2$ causes cancellation.</i>
2(b)	The waves will be twice as far apart/have double the wavelength. The nodal lines will be further apart.	¹ <i>Statement of one relative change</i> <ul style="list-style-type: none"> larger wavelength pattern/nodal lines further apart. 	¹ Both points for achieved plus twice the wavelength.	

Question	Evidence	Evidence contributing to Achievement	Evidence contributing to Achievement with Merit	Evidence contributing to Achievement with Excellence
2(c)		¹ Waves curve around the edge: plus any one of <ul style="list-style-type: none"> • plane waves continue • wavelength correct • arrow on diffracted wave. 	¹ Diagram completely correct. (Note: arrow in continuing direction is redundant.)	
2(d)	Diffraction	¹ Correct answer.		
2(e)	$v = f\lambda$ $f = \frac{v}{\lambda} = \frac{2.0}{1.3} = 1.538 = 1.5$	² Correct answer.		
	unit: Hz or s ⁻¹	¹ Correct unit.		
2(f)	$f = \frac{12}{56.7} = 0.211 \text{ Hz}$ $\lambda = \frac{48}{12} = 4 \text{ m}$ $v = f\lambda = 0.211 \times 4 = 0.847 \text{ m s}^{-1}$ $v = 0.85 \text{ m s}^{-1}$	$v = \frac{d}{t}$ $v = \frac{48}{56.7}$ $v = 0.84 \text{ m s}^{-1}$	² Correct calculation of both f and λ or consequentially correct use of wave equation.	² Correct answer. <ul style="list-style-type: none"> • Velocity determined by fundamental reasoning
	sf	¹ Two sig figs.		

Question	Evidence	Evidence contributing to Achievement	Evidence contributing to Achievement with Merit	Evidence contributing to Achievement with Excellence
3(a)		¹ Correct angle is labelled.		
3(b)	$n_1 \sin \theta_1 = n_2 \sin \theta_2$ $1.66 \sin 19.8^\circ = 1.52 \sin \theta_2$ <hr/> $\theta_2 = \sin^{-1} \frac{1.66 \sin 19.8^\circ}{1.52}$ $(\text{= } \sin^{-1} 0.3699)$	² <i>Correct substitution.</i>	² Achieved <i>plus</i> correct working.	
3(c)	$\frac{n_1}{n_2} = \frac{v_2}{v_1}$ $v_1 = \frac{n_2 v_2}{n_1} = \frac{1.52 \times 1.974 \times 10^8}{1.66}$ $v_1 = 1.81 \times 10^8 \text{ m s}^{-1}$	² <i>Correct substitution (for either v_1 or v_2 look for correct variation of Snell's with angles).</i>	² Achieved <i>plus</i> correct answer.	
3(d)	$n_1 \sin \theta_1 = n_2 \sin \theta_2$ $1.66 \sin c = 1.52 \sin 90^\circ$ <hr/> $c = \sin^{-1} \frac{1.52}{1.66} = \sin^{-1} 0.9157 = 66.3^\circ$	² <i>Correct substitution.</i>	² Achieved <i>plus</i> correct answer.	

Question	Evidence	Evidence contributing to Achievement	Evidence contributing to Achievement with Merit	Evidence contributing to Achievement with Excellence
3(e)	When an incident ray moves from a more dense to less optically dense medium, there exists a Critical angle. If the angle of incidence is equal to this Critical angle, refraction from the normal (angle of refraction) will take place at 90° or along the boundary, and if the angle of incidence is more than the Critical angle, total internal reflection will occur.	¹ Any one of the following <ul style="list-style-type: none"> • A ray incident at θ_c will be refracted at 90°/ boundary. • More dense to less dense. • $\theta \geq \theta_c$ then total internal reflection. • $\theta < \theta_c$ then refraction. 	¹ Any two correctly linked ideas.	¹ Any three ideas correctly linked in a concise manner.
	Total opportunities:	Criterion 1: 10 Criterion 2: 5	Criterion 1: 5 Criterion 2: 5	Criterion 1: 2 Criterion 2: 2

Judgement Statement

The following is a guide to the standard required for each grade in the two criteria.

Criterion 1

Achievement:

Total of 5 opportunities answered at Achievement (or higher)

$5 \times A1$

Achievement with Merit:

Total of 7 opportunities answered with 3 at Merit level (or higher) **and** 4 at Achievement level

$3 \times M1 + 4 \times A1$

Achievement with Excellence:

Total of 8 opportunities answered with 1 at Excellence level **and** 3 at Merit level **and** 4 at Achievement level

$1 \times E1 + 3 \times M1 + 4 \times A1$

Criterion 2

Achievement:

Total of 5 opportunities answered at Achievement (or higher)

$5 \times A2$

Achievement with Merit:

Total of 5 opportunities answered with 3 at Merit level (or higher) **and** 2 at Achievement level

$3 \times M2 + 3 \times A2$

Achievement with Excellence:

Total of SIX opportunities answered with 1 at Excellence level **and** 3 at Merit level **and** 2 at Achievement level

$1 \times E2 + 3 \times M2 + 2 \times A2$

Assessment Schedule

Physics: Demonstrate understanding of mechanics (90255)

Evidence Statement

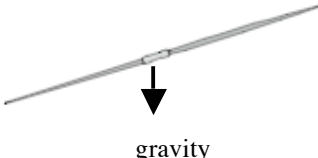
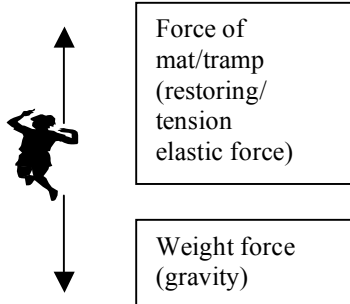
Note: Minor computational errors will not be penalised. A wrong answer will be accepted as correct provided that there is sufficient evidence that the mistake is not due to a lack of understanding of the concepts in physics.

Such evidence could include the following:

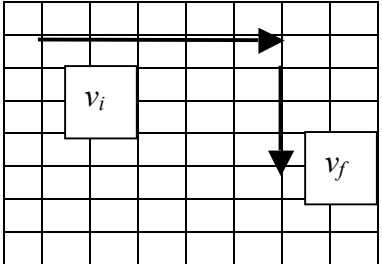
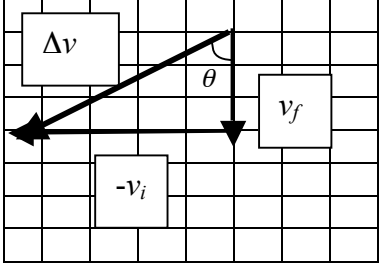
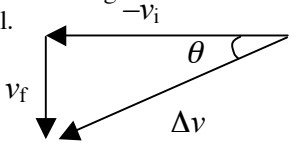
- The last written step before the answer is given has no unexpanded brackets or terms and does not require rearranging.
- The power of any number that is multiplied by a power of 10 is correct.
- Numerical data were wrongly transferred but used correctly.

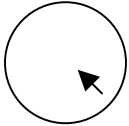
Correct units and significant figures are required only in the questions that specifically ask for them.

Question	Evidence	Evidence contributing to Achievement	Evidence contributing to Achievement with Merit	Evidence contributing to Achievement with Excellence
1(a)	$v_{av} = \frac{d}{t} = \frac{400}{65} = 6.154$ $= 6.2 \text{ m s}^{-1}$	² Correct answer.		
1(b)	$v_f = v_i + at$ $6.0 = 0 + a \times 2.2$ $a = \frac{6.0}{2.2}$ $= 2.7 \text{ m s}^{-2}$	² Correct answer.		
1(c)	$d = v_i t + \frac{1}{2} at^2$ $d = 0 + \frac{1}{2} \times 2.73 \times 2.2^2$ $= 6.6 \text{ m}$	² Correct answer.		
1(d)	$E_K = \frac{1}{2} mv^2 = \frac{1}{2} \times 55 \times 6.5^2$ $= 1200 \text{ J}$	² Correct answer.		
	Unit: joules	¹ joules (accept J or Nm)		
1(e)	$t = \frac{d}{v} = \frac{40}{15} = 2.67$ $P = \frac{W}{t} = \frac{F \times d}{t}$ $F = \frac{P \times t}{d} = \frac{6000 \times 2.67}{40}$ $= 400 \text{ N}$ <p>OR</p> $P = \frac{W}{t} = \frac{F \times d}{t} = F \times v$ $\text{Hence } F = \frac{P}{v} = \frac{6000}{15} = 400 \text{ N}$	² Calculation of t = 2.67 s	² Calculation of $W = Pt$ $= 6000 \times 2.67$ $= 16000 \text{ J}$ ² Derivation of $F = \frac{P}{v}$	² Correct answer for force. ² Correct answer for force.

Question	Evidence	Evidence contributing to Achievement	Evidence contributing to Achievement with Merit	Evidence contributing to Achievement with Excellence
2(a)	Parabola	¹ Parabola (parabolic)		
2(b)	 <p>gravity</p> <p>Arrow not necessarily touching</p>	¹ One force only , vertically downwards, labelled gravity or weight force. Arrow must be below javelin & near centre.		
2(c)	$v_{horiz} = v \cos \theta = 30 \cos 40^\circ$		² Correct working.	
2(d)	$v_{vert} = v \sin \theta = 30 \sin 40^\circ = 19.3$ $vf = vi + at$ $0 = 19.3 - 10.0t$ $t = 1.93 \text{ s}$ <i>Total t = 3.86</i> <i>Range = vt = 88 m</i>	² Calculation of $v_{vert} = 19.3 \text{ m s}^{-1}$	² Calculation of time of flight = 3.86 s <i>Or</i> Complete calculation without doubling <i>t</i> .	² Correct answer. (Note: accept use of either rounded or unrounded data.)
3(a)(i)	$F = kx$ $= 3500 \times 0.50 = 1750 \text{ N}$	² Correct answer. (Ignore sign)		
3(a)(ii)	 <p>(Length of arrows not relevant)</p>	¹ Both forces drawn and labelled correctly, upward force above mat, weight shown as a pull force. (Do not accept support/reaction/normal/thrust nor lift for the upward force.)		
3(a)(iii)	Henry's weight force = $75 \times 10 = 750 \text{ N}$ Net force = $1750 - 750 = 1000 \text{ N}$ (Ignore sign)	² Calculation of weight only or subtraction without conversion to N ($1050 - 75$)	² Correct answer.	
3(a)(iv)	Upwards	¹ Upwards		

Question	Evidence	Evidence contributing to Achievement	Evidence contributing to Achievement with Merit	Evidence contributing to Achievement with Excellence
3(a)(v)	$a = \frac{F}{m} = \frac{1000}{75} = 13.3 \text{ m s}^{-2}$ $= 13 \text{ m s}^{-2}$	² Correct answer.		
3(a)(vi)	$E_p = \frac{1}{2} kx^2 = \frac{1}{2} \times 3500 \times 0.50^2$ $= 437.5 \text{ J}$ $= mg\Delta h$ $\Delta h = \frac{E_p}{mg} = \frac{437.5}{75 \times 10} = 0.58 \text{ m}$ (May also be solved using E_k)	² Calculation of elastic energy stored OR Equates energies with no calculation.	² Calculation of elastic energy stored AND Equates energies	² Correct answer.
3(a)(vii)	Principle of conservation of energy. Assumptions were that no energy was lost (eg to heat [not friction]) and that none was gained (eg by Henry using his muscles/no external force).	¹ Conservation of energy <i>OR</i> correct statement of assumptions.	¹ Conservation of energy <i>AND</i> correct statement of one assumption.	¹ Conservation of energy <i>AND</i> correct statement of both assumptions (ie no gain or loss of energy).
3(b)(i)		¹ All four arrows shown, all pointing in the correct direction.	¹ Achievement <i>plus</i> the weight of the beam is shown in the centre, Nadia's weight is in the correct position and support forces are shown at the supports.	
3(b)(ii)1 3(b)(ii)2	550 N 900 N	² Both answers correct.		
3(b)(iii)	$F_A \times 4.0 = 550 \times 3.0 + 900 \times 2.0$ $F_A \times 4.0 = 1650 + 1800 = 3450$ $F_A = \frac{3450}{4.0} = 862.5 \text{ N}$	² Correct calculation of torque of either weight force about B.	² Correct calculation of torques of both weight forces about B.	² Correct answer.
3(b)(iv)	Since the beam is in equilibrium, the sum of the clockwise torques is equal to the sum of the anticlockwise torques about any chosen point.	¹ Balanced torques <i>OR</i> the beam is in equilibrium.	¹ Both statements correct.	

Question	Evidence	Evidence contributing to Achievement	Evidence contributing to Achievement with Merit	Evidence contributing to Achievement with Excellence
4(a)		¹ Both vectors are the correct length, have arrows in the correct direction and are appropriately labelled.		
4(b)	 <p>(i) $\Delta v = \sqrt{6^2 + 10^2} = 11.66 \text{ m s}^{-1}$</p> <p>$\theta = \tan^{-1}\left(\frac{10}{6}\right) = 59^\circ \text{ or } 31^\circ$</p> <p>(ii) Change in velocity of arrow is 12 m s^{-1} at an angle of 59° from the vertical.</p> 	² Correct value of 12 m s^{-1} only. <i>OR</i> correct angle (must be shown on diagram unless given as a bearing) <i>OR</i> correct diagram.	² Any two correct of speed, angle and direction.	² Diagram and answers all correct.
4(c)	$75 \times 6.0 = (75 + 55)v$ $v = \frac{75 \times 60}{75 + 55} = \frac{450}{130} = 3.5 \text{ m s}^{-1}$	² Correct calculation of Jon's momentum before the collision. <i>OR</i> correct expression for p_f	² Correct answer.	
4(d)	Conservation of momentum. Total momentum does not change during the collision. The assumption is that no external force acts on the skaters (eg skaters do not push/ice has no friction).	¹ Conservation of momentum.	¹ Achieved <i>plus</i> absence of an external force (saying "no friction" is not enough)	

Question	Evidence	Evidence contributing to Achievement	Evidence contributing to Achievement with Merit	Evidence contributing to Achievement with Excellence
4(e)		¹ Arrow points towards centre of circle.		
4(f)	$F_c = \frac{mv^2}{r}$ $v = \sqrt{\frac{F_c \times r}{m}} = \sqrt{\frac{500 \times 0.95}{55}} = 2.939$ $v = 2.9 \text{ m s}^{-1}$	² Correct formula quoted and correct values substituted.	² Correct answer.	
	sf $v = 2.9 \text{ m s}^{-1}$ (2 sf)	¹ Two significant figures.		
4(g)(i)	Ana would travel at a constant speed in a straight line in the direction that she was moving when Jon let go, at a tangent to the circle.	¹ Either travels (in a straight line) at a tangent to the circle OR travels at constant speed.	¹ Travels in a straight line at a tangent to the circle AND at constant speed.	
4(g)(ii)	Ana travels at a tangent to the circle (in a straight line) due to the loss of the centripetal force provided by Jon. She travels at constant speed because the ice provides no friction.		¹ Links tangential movement to absence of Jon's force OR links constant speed to absence of friction.	¹ Links tangential movement to absence of Jon's force AND links constant speed to absence of friction.
	Total opportunities:	Criterion 1: 13 Criterion 2: 15	Criterion 1: 6 Criterion 2: 9	Criterion 1: 2 Criterion 2: 5

Judgement Statement

The following is a guide to the standard required for each grade in the two criteria.

Criterion 1

Achievement:

Total of 7 opportunities answered at Achievement (or higher)

$7 \times A1$

Achievement with Merit:

Total of 7 opportunities answered with 3 at Merit level (or higher) **and** 4 at Achievement level

$3 \times M1 + 4 \times A1$

Achievement with Excellence:

Total of 7 opportunities answered with 1 at Excellence level **and** 2 at merit level **and** 4 at Achievement level

$1 \times E1 + 2 \times M1 + 4 \times A1$

Criterion 2

Achievement:

Total of 8 opportunities answered at Achievement (or higher)

$8 \times A2$

Achievement with Merit:

Total of 8 opportunities answered with 5 at Merit level (or higher) **and** 3 at Achievement level

$5 \times M2 + 3 \times A2$

Achievement with Excellence:

Total of 8 opportunities answered with 2 at Excellence level **and** 3 at Merit level **and** 3 at Achievement level

$2 \times E2 + 3 \times M2 + 3 \times A2$

Assessment Schedule

Physics: Demonstrate understanding of atoms and radioactivity (90256)

Evidence Statement

Question	Evidence	Evidence contributing to Achievement	Evidence contributing to Achievement with Merit	Evidence contributing to Achievement with Excellence
1(a)(i)	0 -1	² Correct numbers.		
	β/e and Beta	¹ Correct symbol and name.		
1(a)(ii)	0 0	² Correct numbers.		
	γ and Gamma	¹ Correct symbol and name.		
1(b)	${}^4_2\text{He} + {}^{234}_{90}\text{Th}$	² Correct numbers.		
	He, α , Helium, He^{2+} in equation	¹ Correct "symbol" for Helium.		
1(c)	Alpha or α	¹ Alpha or α .		
1(d)	Ionising is the ability radiation has to knock electrons out of atoms.	¹ Ionising radiation can cause atoms/air/air particles to become charged.	¹ Ionising radiation can knock electron out of atom causing atoms/air / air particles to become charged/ become ions.	
1(e)	A neutron can spontaneously decay into a proton and an electron.	¹ neutron splits up forming electron.	¹ neutron splits up forming electron and proton.	
1(f)	Alpha particles would have ionised atoms in the jar, grabbed the electrons and changed into a helium atom.	¹ Alpha particles are Helium nuclei/ Helium ions/ He^{2+} / have same atomic and mass number as Helium (but without the electrons).	¹ Alpha particles are Helium nuclei/ Helium ions/ He^{2+} / have same atomic and mass number as Helium and Alpha particles gained electrons and became helium atoms.	¹ Alpha particles are Helium nuclei/ Helium ions/ He^{2+} / have same atomic and mass number as Helium and Alpha particles gained electrons and became helium and Alpha particles became helium atoms by gaining electrons from (ionising) other atoms in the jar.

Question	Evidence	Evidence contributing to Achievement	Evidence contributing to Achievement with Merit	Evidence contributing to Achievement with Excellence
1(g)	Mass number decreases by four. Atomic number decreases by two. Must be an alpha particle and a gamma ray. ${}_{86}^{222}\text{Rn} \rightarrow {}_{84}^{218}\text{Po} + {}_2^4\alpha + \gamma$	² Correct calculation of decrease in atomic no. (2) and mass no. (4) or correct equation(s) with ${}_2^4\alpha$ Or correct equation with ${}_0^0\gamma$ (Note: Naming the emissions by themselves was insufficient for an Achieved in Criterion 2.)	² Correct calculation of decrease in atomic no. (2) and mass no. (4) or equation with ${}_2^4\alpha$ and γ (but no explanation/ calculation for γ).	² Correct calculation of decrease in atomic no. (2) and mass no. (4) or equation with ${}_2^4\alpha$ and γ and numerical calculation that explains γ / explanation why a mathematical calculation is not needed.
2(a)	Otherwise the alpha particles would have been stopped by the molecules of the gases in the air.		¹ Alpha particles have short range in air so would not get to foil/alpha particles cannot penetrate the air so would not get to foil/ alpha particles would have been stopped by the molecules of the gases in the air and so would not get to foil.	
2(b)	Positive or 2+	¹ Positive or 2+		
2(c)	Most of the atom is empty space . Because most of the alpha particles passed through undeviated . There must be something dense and/or positive in the atom. Alpha is positive, and undergoes deflection , so whatever it hit must be dense and/or positive.	¹ Two conclusions described from the key concepts: <ul style="list-style-type: none"> • Most of the atom is empty space/ The nucleus is very small. • There must be something dense in the atom/dense nucleus. • There must be something positive in the atom/positively charged nucleus. 	¹ Two conclusions described from the key concepts. One explanation correctly linked to conclusion.	¹ Two conclusions described from the key concepts. Both explanations correctly linked to conclusion.

Question	Evidence	Evidence contributing to Achievement	Evidence contributing to Achievement with Merit	Evidence contributing to Achievement with Excellence
3(a)	$14 - 6 = 8$	² 8		
3(b)	The time taken for half a radioactive sample to decay into something else.	¹ The time taken for half a radioactive sample to decay into something else/ The time for the activity of a radioactive sample to halve.		
3(c)(i)	$16 \times 20 = 320$ cpm	² 320 cpm (units not required)		
3(c)(ii)	$17\ 100 = 3$ half-lives activity = $\frac{1}{8} \times 320$ = 40 counts/min	² 3 half-lives calculated.	² 40 counts/min (units not required)	
	Unit of counts/min or counts min ⁻¹ or cpm or counts per minute or min ⁻¹ or Bq.	¹ Correct unit.		
3(d)	5.0g.....20 cpm = 4.0 cpm per gram = $\frac{1}{4} \times 16$ cpm per gram this indicates 2 half-lives this indicates 11 400 years OR 5.0 × 16 = 80 cpm for 5.0 g living wood $20/80 = \frac{1}{4}$ of original = 2 half-lives = 2 × 5700 wood died 11 400 years ago.	² 4.0 cpm per gram or 80 cpm for 5 g (unit not required). Or ² Incorrect counts per minute used to correctly calculate a half-life.	² 4.0 cpm per gram or 80 cpm for 5 g (unit not required) and Correct number of half-lives.	² Correct answer of 11 400 years ago. (unit not required).

Notes: Minor computational errors will not be penalised. A wrong answer will be accepted as correct provided that there is sufficient evidence that the mistake is not due to a lack of understanding of the concepts in physics.

Such evidence could include the following:

- The last written step before the answer is given has no unexpanded brackets or terms and does not require rearranging.
- The power of any number that is multiplied by a power of 10 is correct.
- Numerical data were wrongly transferred but used correctly.

Correct units are required only in the questions that specifically ask for them.

Judgement Statement

The following is a guide to the standard required for each grade in the two criteria.

Criterion 1

Achievement

Total of 4 opportunities answered at Achievement (or higher)

4 × A1

Achievement with Merit

Total of 6 opportunities answered with at least 2 at Merit level (or higher) **and** 4 at Achievement level

2 × M1 + 4 × A1

Achievement with Excellence

Total of 8 opportunities answered with 1 at Excellence level **and** 2 at Merit level **and** 5 at Achievement level

1 × E1 + 2 × M1 + 5 × A1

Criterion 2

Achievement

Total of 4 opportunities answered at Achievement (or higher)

4 × A2

Achievement with Merit

Total of 5 opportunities answered with at least 2 at Merit level (or higher) **and** 3 at Achievement level

2 × M2 + 3 × A2

Achievement with Excellence

Total of 7 opportunities answered with 1 at Excellence level **and** 1 at Merit level **and** 5 at Achievement level

1 × E2 + 1 × M2 + 5 × A2

Overall grade allocation:

Criteria	A	M	E
1	4 A/M/E	6 A/M/E including 2 M/E	8 A/M/E including 2 M/E and 1 E
2	4 A/M/E	5 A/M/E including 2 M/E	7 A/M/E including 1 M/E and 1 E

Assessment Schedule

Physics: Demonstrate understanding of electricity and electromagnetism (90257)

Evidence Statement

Note: Minor computational errors will not be penalised. A wrong answer will be accepted as correct provided that there is sufficient evidence that the mistake is not due to a lack of understanding of the concepts in physics.

Such evidence could include the following:

- The last written step before the answer is given has no unexpanded brackets or terms and does not require rearranging.
- The power of any number that is multiplied by a power of 10 is correct.
- Numerical data were wrongly transferred but used correctly.

Correct units and significant figures are required only in the questions that specifically ask for them.

The *Italics* indicate replacement evidence, which must show evidence of a method.

Question	Evidence	Evidence contributing to Achievement	Evidence contributing to Achievement with Merit	Evidence contributing to Achievement with Excellence
1(a)	$R = R_1 + R_2 = 12 \Omega$	² Correct answer.		
1(b)	$I = \frac{V}{R} = \frac{12}{12} = 1.0 \text{ A}$ <i>or consistent with 1 (a)</i>	² Correct answer.		
1(c)	$V = IR = 1.0 \times 4.0 = 4.0 \text{ V}$ <i>or consistent with 1 (b)</i>	² Correct answer.		
1(d)	$P = VI$ $V = IR$ $R = \frac{V}{I} = \frac{V^2}{P} = \frac{16}{3.5} = 4.6 \Omega$ OR $I = \frac{P}{V} = \frac{3.5}{4.0} = 0.875 \text{ A}$ $\Rightarrow R = \frac{V}{I} = \frac{4.0}{0.875} = 4.6 \Omega$		² <i>Correct calculation of current, or correct substitution for $I = \frac{V}{R}$</i>	² Correct method and answer.
1(e)	$R = \frac{R_1 R_2}{R_1 + R_2} + R_3 = 2.14 + 8$ $= 10.14$ $= 10 \Omega$ Nb $\frac{1}{R_p} = \frac{1}{46} + \frac{1}{4}$ $R_p = 2.14 \Omega$	² <i>Correct calculation of parallel combination</i> <i>or idea that $R_T = R_s + R_p$</i>	² Correct method and answer.	

Question	Evidence	Evidence contributing to Achievement	Evidence contributing to Achievement with Merit	Evidence contributing to Achievement with Excellence
1(f)	Adding the CD player in parallel decreases the total resistance. This increases the total current. This increases the voltage across the resistor.	¹ <i>The voltage increases.</i>	¹ <i>Achievement plus The total current increases or resistance decreases.</i>	¹ Voltage increases, plus any two of <ul style="list-style-type: none"> • Current increases • Total resistance decreases • Voltage divider.
1(g)	$I = \frac{V}{R} = \frac{12}{10.14} = 1.2 \text{ A}$ Allow: 10Ω and or rounding eg 1.18A <i>or consistent with 1 (e) or poten. divider</i>	² Correct formula and substitution.		
1(h)	Voltage across 8.0Ω resistor = IR, $1.2 \times 8 = 9.6 \text{ V}$ Voltage across parallel section = $12 - 9.6 = 2.4 \text{ V}$ OR: $V_p = 2.14 \times 1.2 = 2.6 \text{ V}$ <i>or consistent with 1 (g)</i>		² <i>Understanding of the idea that</i> $V_{CD} + V_{8\Omega} = 12 \text{ V}$ <i>or</i> $I_T = \frac{V}{R}$ <i>or voltage ratio</i>	² Correct method and answer.
1(i)	4.0Ω , two 2Ω resistors: series 8.0Ω , two 16Ω resistors: parallel	² <i>One correct.</i>	² Both correct.	
1(j)	Diode only allows current to flow in direction of arrow, so no current flows into CD. This is because the diode's direction opposes current flow.	¹ <i>Idea that current only flows one way in diode/ conven. current or CD does not work.</i>	¹ Achievement plus no current through CD, because current will not flow through the diode.	
2(a)	Electric/Electrical Potential Energy	¹ Correct answer.		
2(b)	Arrow(s) point(s) right to left labelled with electric field or E. <i>Except answer if in part (b).</i>	¹ Correct answer.		
2(c)	$E = \frac{V}{d} = \frac{1100}{3.5 \times 10^{-3}} = 3.1 \times 10^5$	² Correct answer.		
	Vm^{-1} or NC^{-1}	¹ Correct unit.		
2(d)	$F = Eq = 3.1 \times 10^5 \times 1.6 \times 10^{-19}$ $= 5.0 \times 10^{-14} \text{ N}$ <i>or consistent with 2(c)</i>	² Correct answer.		
	2 sf.	¹ Correct sf.		

Question	Evidence	Evidence contributing to Achievement	Evidence contributing to Achievement with Merit	Evidence contributing to Achievement with Excellence
2(e)	Electron will move or deflect towards upper (+) plate.	¹ Correct answer.		
2(f)	Equal and opposite	¹ Correct answer.		
2(g)	Into the page		¹ Correct direction.	
2(h)	$F = Eq$ $F = Bvq$ $Bvq = Eq$ $v = \frac{E}{B} = \frac{3.5 \times 10^3}{1.3 \times 10^{-3}} = 2.7 \times 10^6 \text{ m s}^{-1}$		² <i>Correct statement of $Bvq = Eq$ or correct answer without method shown.</i>	² Correct method and answer.
2(i)(i)	The path is circular/bends/curved. <i>or consistent with 2 (g)</i>	¹ Correct answer.		
2(i)(ii)	The force on the electron is always perpendicular to the electron's velocity, because it provides a centripetal/right angle/right hand slap rule/perpendicular force. <i>or consistent with 2 (g)</i>		¹ <i>Force is downwards or right hand slap rule.</i>	¹ Merit plus clear understanding of the link between the velocity and the centripetal/right angle/right hand slap rule/perpendicular force.
3(a)	Current requires a closed circuit/ this set up is not a closed circuit.	¹ Correct answer.		
3(b)(i)	Upward arrow labelled field, or B.	¹ Correct answer.		
3(b)(ii)	Arrow towards right labelled force.		¹ Correct answer.	
3(c)	Voltage from completed circuit causes electrons to move through the rod. Electrons moving, or current, across magnetic field experience a force. Therefore rod experiences a force/moves.	¹ <i>Any valid single and relevant idea.</i>	¹ <i>Some understanding of force produced as electrons move across field, or current carrying wire in a magnetic field experiences a force.</i>	¹ Correct answer linking current or electron flow at (right) angles/across to the magnetic field and to the force.
3(d)	$I = \frac{V}{R}$ $F = BIL$ $F = B \times \frac{V}{R} \times L$ $F = 0.15 \times 4.8 \times 0.06$ $= 0.043 \text{ N}$ <i>or consistent selection of $L = 0.08\text{cm}$. Nb $v = 0.042 \text{ ms}^{-1}$.</i>	² <i>Correct calculation of current.</i>	² <i>Correct calculation of current, and recognition that $F = BIL$ or incorrect I with correct F for this I.</i>	² Correct method and answer.

Question	Evidence	Evidence contributing to Achievement	Evidence contributing to Achievement with Merit	Evidence contributing to Achievement with Excellence
3(e)	$V = BvL$ $v = \frac{V}{BL}$ $v = 0.056 \text{ m s}^{-1}$ Nb $\frac{5 \times 10^{-4}}{0.15 \times 0.06}$	² <i>Correct formula and either correct rearrangement. or correct substitution.</i>	² Correct method and answer.	
3(f)	Either: Moving rod generates a small current in itself. Current flowing across a magnetic field creates a force. This force opposes the motion of the rod. OR: The moving rod is producing electrical energy. This energy must come from somewhere. It comes from the loss of kinetic energy of the moving rod.	¹ <i>Any single valid and relevant idea.</i>	¹ <i>States that there will be an opposing magnetic force acting on the rod.</i> ¹ <i>Mention of energy or work to create a current.</i>	¹ Clear understanding of the link between the induced current and the opposing force created by it. OR: ¹ Clear understanding of the link between the conversion of kinetic energy into electric energy.

Judgement Statement

The following is a guide to the standard required for each grade in the two criteria.

Criterion 1

Achievement:

Total of 5 opportunities answered at Achievement (or higher)

5 × A1

Achievement with Merit:

Total of 7 opportunities answered with 2 at Merit level (or higher) **and** 5 at Achievement level

2 × M1 + 5 × A1

Achievement with Excellence:

Total of 7 opportunities answered with 2 at Excellence level **and** 2 at Merit level **and** 5 at Achievement level

2 × E1 + 2 × M1 + 5 × A1

Criterion 2

Achievement:

Total of 3 opportunities answered at Achievement (or higher)

3 × A2

Achievement with Merit:

Total of 5 opportunities answered with 2 at Merit level (or higher) **and** 3 at Achievement level

2 × M2 + 3 × A2

Achievement with Excellence:

Total of 7 opportunities answered with 2 at Excellence level **and** 2 at Merit level **and** 2 at Achievement level

2 × E2 + 2 × M2 + 3 × A2