



NEW ZEALAND QUALIFICATIONS AUTHORITY
MANA TOHU MĀTAURANGA O AOTEAROA

Level 3, 2004

Physics

Demonstrate understanding of wave systems (90520)

Demonstrate understanding of mechanical systems (90521)

Demonstrate understanding of atoms, photons and nuclei (90522)

Demonstrate understanding of electrical systems (90523)

National Statistics

Assessment Report

Assessment Schedule

Physics, Level 3, 2004

General Comments

Candidates gaining Achievement were able to identify the physics concepts, phenomena and principles that applied in the general context of the question. They were then able to go on to write descriptions and statements that were relevant to specific aspects of the context.

Candidates who recognised which relationship applied in a given context, and substituted given data, were able to solve straightforward problems. Successful candidates gave their answers to numerical questions with the correct unit of measurement, and rounded their answers to the correct number of significant figures.

Many candidates assessed as Not Achieved, were able to select the appropriate formula and data to solve problems, but were unable to provide descriptive evidence of understanding of the concepts involved.

Candidates gaining Achievement with Merit and Achievement with Excellence were able to see links between concepts, and give explanations that involved reasons.

Physics: Demonstrate understanding of wave systems (90520)

National Statistics

Number of Results	Percentage			
	Not Achieved	Achieved	Merit	Excellence
7,111	38.3%	42.4%	17.1%	2.2%

Assessment Report

Candidates gaining Achievement were able to relate physics terminology, such as frequency and amplitude, to real life experience, such as pitch and loudness. They understood key words such as frequency, wavelength, amplitude, harmonic, overtone and fundamental.

They were also able to identify the particular phenomenon, such as the Doppler Effect, from a description of the results of an experiment, and were able to recognise that different aspects of a physics concept, such as relative velocity in the same direction and in opposite directions, can have an effect on observed results.

Successful candidates were able to identify the key aspect of a physics concept, such as interference, that governs a particular effect. From a description of a series of events, they were able to recognise the relationship that applied, and could substitute given data in order to solve a problem. Answers were given with a unit of measurement, and were rounded to the correct number of significant figures.

Candidates gaining Achievement with Merit and Achievement with Excellence were able to identify at least two key concepts that were relevant in the context of the question, and could link them together with clear reasoning.

Candidates who gave answers that were not completely relevant to the question, were disadvantaged, eg if the question asked about the difference between two frequencies, it was not sufficient for the explanation to involve only one of the frequencies. If the question asked for an explanation of how the effect of interference is experienced in a particular situation, it was not sufficient to give a general explanation of interference.

Physics: Demonstrate understanding of mechanical systems (90521)**National Statistics**

Number of Results	Percentage			
	Not Achieved	Achieved	Merit	Excellence
7,186	29.1%	41.8%	20.8%	8.3%

Assessment Report

Candidates gaining Achievement were able to identify the relationship relevant to a given type of motion, and substitute given data in order to solve a problem. Answers were given with a unit of measurement, and were rounded to the correct number of significant figures. Calculators were put into radian mode when appropriate.

They were able to recognise the conditions that must be present in order for a physics principle, such as the law of conservation of angular momentum, to apply, and could identify the conditions that must be present in order for a phenomenon, such as simple harmonic motion, to be exhibited. They were also able to identify the particular phenomenon, such as resonance, from a description of the conditions that will cause it to be exhibited.

Successful candidates were able to:

- recognise and interpret a relationship, in order to predict what will happen when there is a change in one of the physics quantities involved in the relationship
- identify the key aspect of a physics concept, such as centripetal force acting towards the centre, that governs a particular effect
- give descriptive answers in both diagrammatic and graphical form.

Candidates gaining Achievement with Merit and Achievement with Excellence were able to identify at least two key concepts that were relevant in the context of the question, and could link them together with clear reasoning.

Candidates assessed as Not Achieved lacked knowledge of basic concepts and many did not understand key words such as amplitude, component or angular momentum. Often they did not follow instructions, such as “label forces”, and were sometimes careless in the presentation of their responses, such as drawing a poor sinusoidal shaped graph.

Candidates gaining Achievement with Merit and Achievement with Excellence gave clear and well reasoned explanations of physics concepts linked to the specific context of the question.

Physics: Demonstrate understanding of atoms, photons and nuclei (90522)**National Statistics**

Number of Results	Percentage			
	Not Achieved	Achieved	Merit	Excellence
7,079	48.7%	40.9%	9.2%	1.2%

Assessment Report

Candidates gaining Achievement were able to identify the particular phenomenon that applies in an important context, such as nuclear fusion in the sun.

They were able to identify the relationship that is relevant in a described aspect of a nuclear reaction and substitute given data in order to solve a problem. Answers were given with a unit of measurement and were rounded to the correct number of significant figures.

Successful candidates understood key terms and presented evidence of knowledge of concepts, such as the equivalence of mass and energy, by giving descriptions of how the concepts relate to physics quantities, such as binding energy and mass deficit.

They were able to demonstrate knowledge of concepts, such as energy levels, to allow straightforward problems to be solved. They presented evidence of knowledge of phenomena, such as the photoelectric effect, by describing what happens when it occurs.

Candidates assessed as Not Achieved were confused between concepts, such as binding energy and mass deficit, and between phenomena, such as nuclear fission and fusion.

Candidates gaining Achievement with Merit and Achievement with Excellence gave explanations that showed evidence of a good understanding of concepts and phenomena.

Physics: Demonstrate understanding of electrical systems (90523)

National Statistics

Number of Results	Percentage			
	Not Achieved	Achieved	Merit	Excellence
7,170	50.9%	30.4%	14.5%	4.2%

Assessment Report

Candidates gaining Achievement were able to:

- identify or describe aspects of electrical systems, by writing statements using appropriate physics terminology such as “lead” and “lag” with reference to phase, and “impedance” when both reactance and resistance are present
- sketch graphs with sufficient care that the key concept that was being shown, such as voltage drop after one time constant, could be readily identified
- show evidence of knowledge and application of concepts by accurately labelling diagrams and by writing descriptions that were relevant in the given context
- solve straightforward problems by selecting the correct formula and substituting data
- round their answers to the correct number of significant figures.

Candidates assessed as Not Achieved, lacked the skills and knowledge to identify aspects of physics appropriate to the context, and often used incorrect or inappropriate terminology. Many candidates attempted to apply Level 2 techniques to solve problems, such as those involving Kirchhoff’s Laws.

Candidates gaining Achievement with Merit and Achievement with Excellence, were able to link the physics phenomena, concept or principle clearly to the context of the question, and to make links between two or more physics phenomena, concepts or principles. Their explanations were clear, with little irrelevant information, and used terminology correctly. Their solutions showed evidence of understanding how relationships can be linked.

Assessment Schedule

Physics: Demonstrate understanding of wave systems (90520)

Evidence Statement

	Evidence	Judgement	Grade
	Correct units given with numerical answers Correct sig fig	At least 3 answers have a correct unit. Q2(c) given to 2 sig fig	A1
1(a)	Doppler Effect	Correct answer.	A1
1(b)	$f = f \frac{v_w}{v_w - v_s} \Rightarrow v_w = \frac{437 \times 8.6}{437 - 426} = \frac{3758.2}{11} (= 341.65)$ <p>or</p> $v_w = \frac{8.6}{(1 - \frac{426}{437})} = \frac{8.6}{0.02517} (= 341.65)$	Final calculation is from a re-arrangement that has v_w as its subject.	M2
1(c)	The frequencies are different because when the horn is moving toward the recorder their relative movement causes an apparent reduction in the wavelength of the wave; when it is moving away the apparent wavelength is greater. The speed of the wave that reaches the recorder is always the true speed. As $v = f\lambda$ the frequency is inversely proportional to the wavelength and so the pitch will go from high to low.	One correct and relevant statement that relates to the wavelength being shorter on approach or longer on retreat.	A1
		Size of both frequencies, explained in terms of the change in wavelength and the inverse relationship.	M1
1(d)	$f = f \frac{v_w}{v_w + v_s} = \frac{426 \times 341.65}{341.65 + 8.6}$	$v_s = 31$ substituted instead of $v_s = 8.6$ / v_w minus v_s used	A2
		Correct answer	M2
1(e)	When the source is not moving directly in line with the observer the velocity of the source relative to the observer gradually reduces on approach and gradually increases on retreat. As the velocity of the source relative to the observer determines the difference between the true and apparent wavelengths, the apparent wavelength will change gradually from smaller to larger and so the frequency will change gradually from higher to lower.	Idea that the difference between the direction of the source and direction of the wave (the velocity of source relative to observer) is the key issue.	A1
		The gradual change in frequency of the sound reaching the observer is linked to an explanation of why there is a gradual change in velocity of the source relative to the observer / apparent wavelength of the wave.	M1
		Explanation is clear, concise and complete.	E1
1(f)	Beats are produced when two waves of similar frequency are heard together. As the waves arrive they combine in or out of phase giving a combined displacement that varies regularly in amplitude. As amplitude is a measure of loudness, the sound varies regularly in loudness.	One correct and relevant statement that recognises the difference in the frequencies is the key issue.	A1
		Link made between the variation in loudness and the waves arriving at the observer sometimes combining constructively and sometimes destructively. The difference between the frequencies is recognised to be small.	M1
		Explanation is clear and concise and makes reference to the regular variation of the combined displacement (amplitude) of the two waves.	E1

	Evidence	Judgement	Grade
1(g)(i)	Either 420 Hz or 430 Hz	425 ± 5 Hz explicit or implied.	A2
1(g)(ii)	A decrease in beat frequency means the two frequencies are getting closer together. The signal generator frequency must therefore be increasing up towards the recorded frequency. This means the recorded frequency must be 430 Hz.	The two frequencies are getting closer together.	A1
		Frequencies getting closer together linked to signal generator frequency increasing to reach the recorded frequency.	M1
2(a)	$v = f\lambda \quad \lambda = \frac{340}{426} = 0.79812 = 0.80 \text{ m}$ For an open pipe $\lambda = 2L \Rightarrow \lambda = 0.20 \times 2 = 0.40 \text{ m}$ For a closed pipe $\lambda = 4L \Rightarrow \lambda = 0.20 \times 4 = 0.80 \text{ m}$	Correct wavelength calculated	A2
		Wavelength is consistent with $\lambda = 4L$ where L is the length of a closed pipe.	M2
		$\lambda = 4L$ is shown not to link with an open pipe.	E2
2(b)	$\lambda = \frac{0.20}{1.75} / \frac{0.20 \times 4}{7} = 0.11429 \text{ m}$	Correct working	M2
2(c)	$v = f\lambda \quad f = \frac{340}{0.11429} = 2975 = 3.0 \times 10^3 \text{ Hz}$	Correct answer	A2
2(d)	$\frac{2975}{426} = 6.98 \therefore 7^{\text{th}}$ harmonic	Answer 7 given (not 6.98)	A2
2(e)	unit \propto watts and $\propto \frac{1}{\text{m}^2} \therefore \text{W m}^{-2} / \text{kg s}^{-3} / \text{J s}^{-1} \text{m}^{-2}$	Correct unit	M1
3(a)	As the students walk from A to B they cross antinodal and nodal lines. At antinodal lines they hear loud sound because the sound waves from the two sources arrive in phase and add constructively. At nodal lines they hear soft sound because the sound waves from the two sources arrive with opposite phase and add destructively.	One correct and relevant statement.	A1
		Constructive and destructive interference is explained in terms of phase / crests and troughs / path difference.	M1
		Explanation relates to what the students hear as they walk from A to B. It is not just a general explanation of interference.	E1
3(b)	$\lambda = d \sin \theta, \theta = \tan^{-1} \left(\frac{5.60}{15.0} \right)$ $\Rightarrow \lambda = 0.360 \times \sin 20.4723 = 0.12591$ or: $\lambda = S_2B - S_1B = 16.075 - 15.949$	Answer consistent with use of $\lambda = \frac{dx}{L}$	A2
		Correct formula and working, including (if relevant) how θ is calculated.	E2
3(c)	$v = f\lambda \Rightarrow v = 2680 \times 0.12591 = 337.443 = \mathbf{337 \text{ m s}^{-1}}$	Correct calculation	A2

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

3 × M1 + 2 × A1

Achievement with Excellence:

Total of 5 opportunities answered with 1 at Excellence level **and** 3 at merit level **and** 1 at Achievement level

1 × E1 + 3 × M1 + 1 × A1

Criterion 2

Achievement:

Total of 3 opportunities answered at Achievement (or higher)

3 × A2

Achievement with Merit:

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

3 × M2 + 2 × A2

Achievement with Excellence:

Total of 5 opportunities answered with 1 at Excellence level **and** 3 at merit level **and** 1 at Achievement level

1 × E2 + 3 × M2 + 1 × A2

Assessment Schedule

Physics: Demonstrate understanding of mechanical systems (90521)

Evidence Statement

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

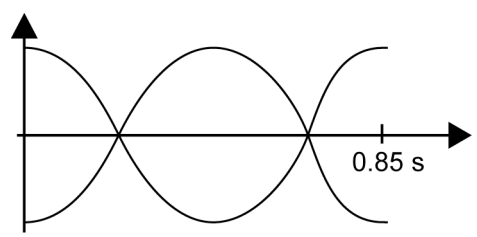
Such evidence can include the following:

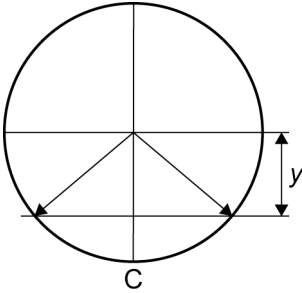
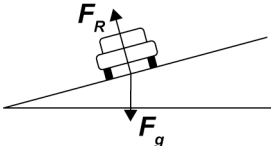
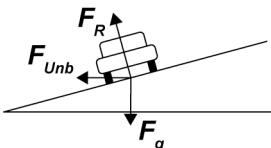
- the last written step before the answer is given has no unexpanded brackets or terms and does not require rearranging
- the power of any number that is multiplied by a power of 10 is correct
- a value has been incorrectly transcribed from the question
- consequential information used correctly from previous questions

A given number of correct units are required. Significant figures are required only in the question that specifically asks for them.

Italics indicate replacement evidence.

	Answer	Judgement	Grade
1(a)	$\omega = \frac{2\pi}{20.0}$ (= 0.31416 rad s ⁻¹) $\omega = \frac{\delta\varphi}{\delta t}$	Correct substitution. Must have substitution and not just formula and answer.	A2
1(b)	$KE_{\text{rot}} = \frac{1}{2} I \omega^2 = 0.5 \times 3.50 \times 10^4 \times 0.314^2$ = 1725 = 1730 J	Correct answer. Allow use of rounded or unrounded ω .	A2
1(c)(i)	$L = I \omega$ = $3.50 \times 10^4 \times 0.31416 = 10\,995.6 = 11\,000 \text{ kg m}^2 \text{ s}^{-1}$	Correct answer. Allow use of rounded or unrounded ω .	A2
1(c)(ii)	Yes L is conserved – no net external torques/forces acting/speed is constant/rotational inertia is constant	Yes plus answer gives a reason for L to be conserved. (No and reason – not accepted.)	A1
1(d)	$\alpha = \frac{\omega}{t}$ = $\frac{0.200}{17.2}$ (= 0.011628 rad s ⁻¹)	Correct substitution. Must have substitution and not just formula.	A2
1(e)	External torque $I\alpha = Fr$	<i>Calculation of $I\alpha$ or Fr.</i>	M2
	$I\alpha = 3.5 \times 10^4 \times 0.011628 = 406.98$ $F = \frac{406.98}{1.375} = 295.9854 = 296 \text{ N}$	Correct answer links $I\alpha$ and Fr as the external torque. Note: power of 10 calculator error is not allowed as computational error. Allow use of rounded or unrounded α .	E2

	Answer	Judgement	Grade	
1(f)	Changing from iron to wood will decrease the mass of the wheel/wheel is lighter. For the same dimensions, this will decrease rotational inertia, I . Hence, for the same τ then α will increase.	<i>Answer can show that I will decrease if mass of wheel decreases.</i>	A1	
		Explanation must identify that mass of wheel and hence I will decrease and be able to link this to increased angular acceleration.	M1	
		Clear, concise explanation covers all main points. Link between I and α must show awareness of τ being constant.	E1	
2(a)	$2 \times 0.14 = 0.28 \text{ m}$	Correct answer.	A2	
2(b)	$T = 2\pi\sqrt{\frac{m}{k}}$ $0.85 = 2\pi\sqrt{\frac{62.0}{k}}$ $k = 4 \times \pi^2 \times 62.0 \div 0.85^2 = 3387.8$ $k = 3.4 \times 10^3 \text{ N m}^{-1}$	Correct working. Must have substitution and not just formula and answer	M2	
		Correct (2) sf.	A1	
2(c)	$T = \frac{2\pi}{\omega}$ $\omega = \frac{2\pi}{0.85} = 7.39198 \quad T = 1/f \text{ and } \omega = 2\pi f$ $\omega = 7.4 \text{ rad s}^{-1}$	Correct answer.	M2	
2(d)		Sinusoidal shape. (cos). sine allowed with correct time.	A1	
		Sinusoidal shape. Graph starts at max $\pm a$. A value of T on x axis. Value of max a not needed. If many cycles are drawn, time for one cycle has to be clearly indicated.	M1	
2(e)(i) 2(e)(ii)	B $v = A\omega$ $v = 0.14 \times 7.39198 = 1.0349 \text{ ms}^{-1} = 1.0 \text{ ms}^{-1}$	Correct answer.	M2	
2(f)	$PE = \frac{1}{2}ky^2$ $PE = 0.5 \times 3387.8 \times 0.14^2$ $PE = 33.20$ $PE = 33 \text{ J}$	$PE = \text{Max KE}$ $PE = \frac{1}{2}mv^2$ $PE = 0.5 \times 62 \times 1.0349^2$ $PE = 33.20$ $PE = 33 \text{ J}$	Idea that at A or C is max PE. Correct value.	M2

	Answer	Judgement	Grade
2(g)(i)		Correct position diagram but required displacement not indicated or incorrectly indicated from C. Position could be clockwise or anticlockwise from C	A1
		Correct displacement indicated. Allow no arrow on phasor or a point drawn on ref circle if y is clearly labeled.	M1
2(g)(ii)	$y = 0.14 \times \cos 45^\circ$ $y = 0.09899$ $y = 0.099 \text{ m}$	Correct answer, consistent with diagram in 2(g)(i)	A2
2(h)	<p>Motion is not SHM because F or a is not proportional to y anymore/the motion is not oscillating about a fixed equilibrium point anymore. Above the mat his acceleration is the constant acceleration due to gravity/force is the constant weight.</p>	Explanation shows main difference between SHM and this motion.	M1
		Clear, concise explanation covers all main points. Clear explanation that acceleration is the constant acceleration due to gravity.	E1
2(i)	$E_{\text{TOT}} = E_K + E_P$ $E_K = \frac{1}{2}mv^2 = 0.5 \times 62 \times 2.4^2 = 178.56$ $E_{\text{TOT}} = 54.5 + 178.56 = 233.06$ $E_{\text{TOT}} = \frac{1}{2}ky^2$ $\Rightarrow y = 0.37 \text{ m}$	Calculation of y from E_K or E_P given, or incorrect total energy from values of E_K and E_P	A2
		Correct calculation of total energy or correct calculation of amplitude consistent with incorrect idea re total energy.	M2
		Correct answer.	E2
2(j)	Resonant/natural frequency.	Correct answer.	A1
3(a)		Both vectors correctly labelled and with correct arrows. Evidence may come from outside the diagram provided it compliments what is drawn on the diagram.	A1
3(b)		Correctly labelled force with correct arrow. Size not important.	A1
3(c)	<p>Vertical component = F_g $F_g = mg = 995 \times 9.80 = 9751 = 9750 \text{ N}$</p>	Correct answer. Allow use of $g = 10 \text{ ms}^{-2}$	M2

	Answer	Judgement	Grade
3(d)	The horizontal component of the reaction force provides the centripetal force (unbalanced force acting toward the centre) to create circular motion. (Evidence of knowledge that unbalanced force acts towards the centre can be taken from (b).)	A centripetal force is acting.	A1
		Link made between the requirement for a centripetal force and the force that provides the centripetal force.	M1
3(e)	$F_R = \frac{mg}{\cos\phi} = \frac{9751}{\cos 6.5} = 9814 \text{ N}$ $F_C = F_R \sin\phi = 9814 \times \sin 6.5 = 1110.986 \text{ N}$ $1110.986 = \frac{mv^2}{r}$ $v = 100.49 = 10.0 \text{ ms}^{-1}$ <p>OR</p> $\frac{mv^2}{r} = F_R \sin\phi$ $mg = F_R \cos\phi$ $\frac{v^2}{rg} = \tan\phi$ $v^2 = 90.0 \times 9.80 \times \tan 6.50^\circ = 100.49$ $v = 10.0 \text{ m s}^{-1}$	Correct calculation of horizontal component or calculation of v correct consistent with an incorrect calculation of horizontal component.	M2
		Correct answer. $F_R = F_c$ or $mg = F_c$ not acceptable	E2
3(f)	The increased angle would mean that the horizontal component of the reaction force would have to be greater, thus providing a greater horizontal (centripetal) force. If friction is to be zero, and radius is constant, the speed would have to increase until this horizontal force is the centripetal force.	<i>Some understanding that the horizontal (centripetal) force would be greater, or speed is increased.</i>	A1
		Link made between increased angle causing an increased centripetal force (horizontal component of F_R) and the greater speed that the increased centripetal force requires.	M1
		Clear, concise explanation covers all main points. Link between F and v made to show why v increases should be clear.	E1

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 6 opportunities answered with 3 at Merit level (or higher) **and** 3 at Achievement level

3 × M1 + 3 × A1

Achievement with Excellence:

Total of 6 opportunities answered with 2 at Excellence level **and** 1 at Merit level **and** 3 at Achievement level

2 × E1 + 1 × M1 + 3 × A1

Criterion 2

Achievement:

Total of 3 opportunities answered at Achievement (or higher)

3 × A2

Achievement with Merit:

Total of 6 opportunities answered with 3 at Merit level (or higher) **and** 3 at Achievement level

3 × M2 + 3 × A2

Achievement with Excellence:

Total of 7 opportunities answered with 2 at Excellence level **and** 2 at Merit level **and** 3 at Achievement level

2 × E2 + 2 × M2 + 3 × A2

Grade distribution and sufficiency table:

	A		M		E	
1	Units: 5 correct required SF: 2b 1c(ii), 2d, 2g(i), 2j 3a, 3b, 3d	5/9	1f 2d, 2g(i), 2h 3d, 3f	6 / 12 incl 3 at M or better	1f 2h 3f	6 / 12 incl 1 at M plus 2 at E
2	1a, 1b, 1c(i), 1d 2a, 2g(ii)	3 / 6	2b, 2c, 2e, 2f, 3c	6 / 11 incl 3 at M or better	1e 2i 3e	7 / 14 incl 2 at M plus 2 at E

Assessment Schedule

Physics: Demonstrate understanding of atoms, photons and nuclei (90522)

Evidence Statement

	Answer	Judgement	Grade
	Correct units given with numerical answers. Correct use of sig fig.	At least 3 answers have a correct unit.	
1(a)	Fusion	Correct answer.	A1
1(b)	$\Delta m = (3.3436 + 1.6726 - 5.0064) \times 10^{-27}$ $= (5.0162 - 5.0064) \times 10^{-27}$ $= 9.8 \times 10^{-30} \text{ kg}$ <p>(This is a SHOW question.)</p>	Correct calculation. Ignore sign.	A2
1(c)	$E = mc^2 = 9.8 \times 10^{-30} \times (3.00 \times 10^8)^2$ $= 8.82 \times 10^{-13} \text{ J}$ $= 8.82 \times 10^{-13} \div 1.60 \times 10^{-19} \text{ eV}$ $= 5.5125 \times 10^6$ $= 5.5 \text{ MeV}$	Correct answer in joules or correctly divides by 1.60×10^{-19}	A2
		Correct answer in eV. (5.5×10^6 eV or 5.5 MeV)	M2
1(d)	$\Delta m = 4 \times 1.6726 \times 10^{-27} +$ $2 \times 0.000911 \times 10^{-27} - 6.6447 \times 10^{-27}$ $= 4.7522 \times 10^{-29}$ $6E_\gamma = 4.7522 \times 10^{-29} \times (3.00 \times 10^8)^2$ $- 2 \times 4.005 \times 10^{-14}$ $E_\gamma = 6.9948 \times 10^{-13}$ $f_\gamma = \frac{E_\gamma}{h} = 1.0550 \times 10^{21}$ $= 1.06 \times 10^{21} \text{ Hz}$	Correct Δm or correct consistent calculation of E_γ or two significant errors.	A2
		Correct E_γ or consistent f_γ from incorrect mass or one significant error.	M2
		Correct frequency.	E2
1(e)(i)	$\Delta m = (1.6726 + 1.6749 - 3.3436) \times 10^{-27}$ $= 3.9 \times 10^{-30} \text{ kg}$	Correct answer (ignore sign).	A2

	Answer	Judgement	Grade
1(e)(ii)	There is a mass deficit because energy is released in the form of radiation and KE when the nucleus is formed. The binding energy is the energy that must be supplied to the nucleus to break it into its constituent protons and neutrons. The mass deficit $\times c^2$ has the same value as the binding energy of the nucleus.	<ul style="list-style-type: none"> The mass deficit is (the equivalent of) binding energy. Inside a nucleus nucleons have lower mass than when free particles. Inside a nucleus nucleons have lower energy than when free particles. Energy is released (from the nucleus). 	A1
	Energy has to be supplied to the nucleus because the energy of nucleons in the unbound state is greater than their energy in the bound state. This is the binding energy. NOTES Clear and concise means clear and concise physics principles with minimal irrelevancies. Accept weight as well as mass in argument (for A). Accept reactants and products.	Some understanding is shown of the link between mass deficit and the release of energy (in the form of KE and radiation) when the nucleus is formed OR Some understanding is shown of the link between binding energy and the energy that is needed to be supplied to break the nucleus into its constituent particles OR Some understanding is shown of the link between binding energy and the mass deficit times c^2 being the same numerical value.	M1
		The explanation of any of merit points is clear and concise.	E1
2(a)(i)	$E_2 = \frac{-hcR}{n^2}, n = 2$ $= -\frac{1}{4}(6.63 \times 10^{-34} \times 3.00 \times 10^8 \times 1.10 \times 10^7)$ $= -5.46975 \times 10^{-19} = 5.47 \times 10^{-19} \text{ J}$ <i>Their answer correct to 3sf</i>	Correct answer, negative not needed.	A2
2(a)(ii)	$\frac{1}{\lambda} = R \left(\frac{1}{s^2} - \frac{1}{L^2} \right)$ $= 1.10 \times 10^7 \times \left(\frac{1}{2^2} - \frac{1}{5^2} \right) = 2\,310\,000$ $\lambda = 4.329 \times 10^{-7} \text{ m}$	Correct answer (ignore sign).	M2
2(b)	$\Delta E = hf$ $\Rightarrow f = \frac{5.46975 \times 10^{-19}}{6.63 \times 10^{-34}}$ $= 8.25 \times 10^{14} \text{ Hz}$ Watch consistency from 2a(i) = $\frac{2a(i)}{6.63 \times 10^{-34}}$	Correct or consistent answer.	M2

	Answer	Judgement	Grade
2(c)	<p>The transition from $n = 3$ to $n = 2$ The lowest frequency is produced by the smallest energy emission.</p> <p>as $\Delta E = hf$ or $\Delta E \propto f$</p> <p>Therefore, as energy level is $= (-) \frac{hcR}{n^2}$</p> <p>so $\Delta E \propto \frac{1}{2^2} - \frac{1}{L^2}$</p> <p>For ΔE to be smallest $L=3$</p> <p>OR</p> <p>As $f \propto \frac{1}{\lambda} = R \left[\frac{1}{2^2} - \frac{1}{L^2} \right]$ for f to be smallest $\frac{1}{\lambda}$ must be small so L must be 3.</p> <p>OR</p> <p>Uses a diagram showing correctly labelled energy levels with jumps shown</p> <p>OR</p> <p>They could use calculation to justify jump is from $n = 3$ (eg E_3 and E_4 calculated and compared to E_2).</p>	<p>The transition from $n = 3$ (to $n = 2$).</p> <p>The lowest frequency is produced by the smallest energy emission. (or $\Delta E \propto f$)</p> <p>The smallest energy jump will be from the level above.</p>	A1
		<p>$n = 3$ and link is made between the lowest frequency coming from the smallest energy jump (or $\Delta E \propto f$) and this being from one level above destination level.</p> <p>OR</p> <p>States that $f \propto \frac{1}{\lambda} = R \left[\frac{1}{2^2} - \frac{1}{L^2} \right]$ OR similar. If they justify $L=3$ then this could become excellence.</p>	M1
		<p>Explanation is clear and concise.</p> <p>They must justify as clearly and concisely as possible why $n = 3$ gives the least ΔE.</p> <p>See answer column for some examples.</p>	E1
	<i>Unit and significant figure mark to be entered here.</i>	<i>(2a) 5.47×10^{-19} (J) or their answer must be rounded to 3sf AND Must get units for 3 of 1e(i), kg, 2a(i) J, 2a(ii) m, 2b Hz, 1d Hz, 3c m</i>	A1
3(a)	To attract electrons.	Correct answer.	A1
3(b)	Sunlight contains photons of many different frequencies. Photons incident on the emitter plate give up their energy to the electrons. If this energy is greater than or equal to the work function (or their frequency is greater than the threshold frequency) they will be immediately attracted to the positive collector plate. Thus a circuit will be formed (or there will be a flow of electrons from emitter to collector plate and so an electric current in the circuit).	<p>Photons (or equivalent) incident on the emitter plate give up their energy to the electrons.</p> <p>Photons cause electrons to be released from the emitter plate.</p>	A1
		Some link made between the release of electrons and the requirement for the photons to have a minimum energy greater than or equal to work function , or good equivalent statement (or frequency greater than threshold frequency).	M1
		<p>Clear and concise explanation of merit ideas plus the following:</p> <p>There is a flow of electrons across the gap (or from one plate to the other) and therefore the completion of the circuit.</p>	E1

	Answer	Judgement	Grade
3(c)	$hf_{\min} = \phi, \quad v = f_{\min}\lambda_{\max}$ $f_{\min} = \frac{3 \times 10^{-19}}{6.63 \times 10^{-34}} =$ $= 4.524886 \times 10^{14} \text{ Hz}$ $\Rightarrow \lambda_{\max} = \frac{3.00 \times 10^8 \times 6.63 \times 10^{-34}}{3.0 \times 10^{-19}}$ $= 6.6(3) \times 10^{-7} \text{ m}$	Correct minimum frequency OR consistent λ_{\max} from their frequency.	M2
		Correct answer.	E2

Judgement Statement

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

Criterion 1

Achievement:

Total of 3 opportunities answered at Achievement (or higher)

3 × A1

Achievement with Merit:

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

2 × M1 + 2 × A1

Achievement with Excellence:

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

1 × E1 + 2 × M1 + 1 × A1

Criterion 2

Achievement:

Total of 3 opportunities answered at Achievement (or higher)

3 × A2

Achievement with Merit:

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

2 × M2 + 2 × A2

Achievement with Excellence:

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

1 × E2 + 2 × M2 + 1 × A2

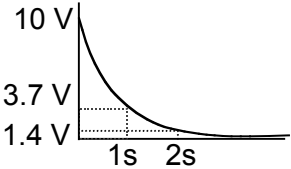
Grade distribution and sufficiency table:

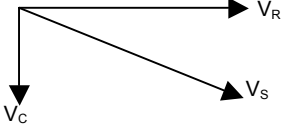
	A		M		E	
1	units & sf 1(a) 1(e) 2(c) 3(a), 3(b)	3	1(e)(ii) 2(c) 3(b)	4 2 at M or better	1(e)(ii) 2(c) 3(b)	4 with at least 1 at E plus 2 at M
2	1(b), 1(c), 1(e)(i) 2(a)(i)	3	1(c) 2(a)(ii) 2(b)	4 2 at M or better	1(d) 3(c)	4 including 1 at E plus 2 at M

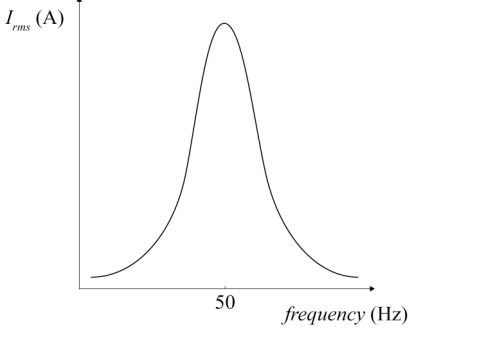
Assessment Schedule

Physics: Demonstrate understanding of electrical systems (90523)

Evidence Statement

Question	Evidence	Evidence contributing to Achievement	Evidence contributing to Achievement with Merit	Evidence contributing to Achievement with Excellence
1(a)	$I = \frac{P}{V} = 4.5 \div 6.25 = 0.72 \text{ A}$	Correct answer. A2		
1(b)	$R_f = \frac{V}{I} = (6.40 - 6.25) \div 0.72 = 0.20833$ $= 0.21 \Omega$		Correct answer. M2	
1(c)	$I_{\text{battery}} = 0.250 + 0.208 = 0.458 \text{ A}$	Correct answer. A2		
1(d)	Clockwise around bottom loop: $- 0.458 \times R + 6.90 - 6.4 - 0.208 \times 1.8 = 0$ $0.458 \times R = 0.1256$ $R = 0.2742 = 0.27 \Omega$ OR Around outer loop $6.90 - 6.40 - 1.5 \times 0.250 - 0.458 \times R = 0$ $R = 0.273 = 0.27 \Omega$		Correct substitution and signs OR correct answer. M2	
1(e)	$\tau = RC = 8.7 \times 0.115 = 1.0 \text{ s}$	Correct answer. A2		
1(f)		Decay curve, does not cut time axis. A1	Plotted values are: $t = 0 \text{ s} : V = 10 \text{ V}$ plus two other correctly plotted points. M2	
1(g)	Voltage that will give a power of 1.3 W is $V^2 = P \times R = 1.3 \times 8.7 \Rightarrow V = 3.4 \text{ V}.$ From the graph: at $V = 3.4 \text{ V}$, $t = 1.1 \text{ s}$ OR exponential calculation.		Correct voltage. M2	Correct answer. E2
2(a)	Change in voltage causes charge to flow on and off capacitor plates continuously, giving a continuous current so the lamp is always alight. At high frequency the rate at which the capacitor stores and releases charge is enough that there is no visible flicker.	Answer shows some idea of capacitor appearing to pass AC OR No current in DC because it is not a closed circuit. OR Idea of high frequency – no flicker. A1	Correct answer shows understanding of the continuous flow of electrons to and from the capacitor. M1	

Question	Evidence	Evidence contributing to Achievement	Evidence contributing to Achievement with Merit	Evidence contributing to Achievement with Excellence
2(b)		All phasors are labelled correctly. A1		
2(c)	$\omega = 2\pi f = 2\pi \times 50$ $= 314.16$	Correct working shown. A2		
2(d)	$X_C = \frac{1}{\omega C} = \frac{1}{314.16 \times 2.20 \times 10^{-4}}$ $= 14.469 \Omega$ $\Rightarrow Z = \sqrt{X_C^2 + R^2}$ $= \sqrt{14.469^2 + 16^2} = 21.572 \Omega$	<i>Reactance of C calculated correctly.</i> OR <i>C substitute instead of X_C.</i> A2	<i>Correct Z consistent with incorrect calculated value of X_C.</i> M2.	Correct answer. E2
2(e)	$X_L = X_C = 14.47 \Omega$ $14.47 = \omega L$ $L = 14.47/314$ $L = 0.046 \text{ H}$ <p>OR</p> $f_o = \frac{1}{2\pi\sqrt{LC}}$ $f_o^2 = \frac{1}{4\pi^2 \times L \times 2.20 \times 10^{-4}}$ $\Rightarrow L = \frac{1}{4\pi^2 \times L \times 2.20 \times 10^{-4} \times 50.0^2}$ $= 0.046 \text{ H}$		Correct answer. M2	
2(f)	<p>If the frequency of the AC supply to an LCR circuit is varied, the current will have a maximum value at a particular frequency. X_C decreases with frequency as X_L increases with frequency. Since V_C lags V_S by 90° and V_L leads V_S by 90°, V_C and V_L are 180° out of phase. Thus if V_C and V_L are equal in value they cancel out and the circuit has minimum impedance.</p> <p>OR</p> <p>A resonant circuit is one in which the supply frequency is equal to the frequency at which energy naturally oscillates between the electric field in the capacitor and the magnetic field in the inductor. This results in the supply reinforcing the current in time with the natural frequency; as a result the total energy being transferred is a maximum. The circuit current reaches a peak value at this frequency.</p>	One correct characteristic of resonant circuit identified Current is maximum OR $V_C = V_L$ OR $X_C = X_L$ OR $V_S = V_R$ OR $Z = R$ OR supply frequency = natural frequency. A1	Maximum current is explained in terms of $X_C = X_L$ causing minimum impedance. OR Maximum current explained in terms of driving frequency equals natural frequency. M1	Maximum current explained in terms of minimum impedance due to phase relationships in the circuit. OR Maximum current explained in terms of supply frequency reinforcing the energy transfer between the inductor and capacitor. E1

Question	Evidence	Evidence contributing to Achievement	Evidence contributing to Achievement with Merit	Evidence contributing to Achievement with Excellence
2(g)	$I = \frac{V}{R} = \frac{12.0}{16.0} = 0.750 \text{ A}$	Correct answer. A2		
2(h)		Correct shaped graph with resonant frequency indicated. A1		
3(a)	Changing flux / current in one coil induces a voltage / current in another coil.	Correct concept. A1		
3(b)	$\begin{aligned} \phi &= BA \\ &= 4.20 \times 10^{-3} \times 2.00 \times 10^{-2} \\ &= 8.40 \times 10^{-5} \text{ Wb} \end{aligned}$ <p>($\times 150 = 0.0126 \text{ Wb}$)</p>	Correct answer. (Accept answer if it has been multiplied by 150.) A2		
3(c)	The current and hence the flux in the coil falls to zero. Because the flux in the primary coil is changing a voltage is induced. The induced voltage is in a direction to keep the current flowing.	Any correct and relevant statement. Eg: current or flux is changing. Lenz's Law A1	Link between changing flux in the primary and induced voltage. M1	
3(d)	$\begin{aligned} \varepsilon &= -\frac{\Delta\phi}{\Delta t} \text{ (for each turn)} \\ &= 85 = 150 \times \frac{\Delta\phi}{\Delta t} \\ \Rightarrow \Delta t &= 150 \times \frac{8.40 \times 10^{-5}}{85.0} \\ &= 1.48235 \times 10^{-4} \text{ s} \end{aligned}$		Correct working. M2	
3(e)	$\begin{aligned} \varepsilon &= -L \frac{\Delta I}{\Delta t}, \quad V = IR \\ \Rightarrow I &= \frac{12}{0.75} = 16 \text{ A} \Rightarrow \Delta I = 16 \text{ A} \\ L &= \frac{85.0 \times 1.48235 \times 10^{-4}}{16} \\ &= 7.875 \times 10^{-4} \text{ H} \end{aligned}$		Correct substitution to calculate L consistent with incorrect ΔI . M2	Correct working. E2
3(f)(i)	$\begin{aligned} \tau &= \frac{L}{R} = \frac{7.875 \times 10^{-4}}{0.750} \\ &= 1.105 \times 10^{-3} = 1.1 \times 10^{-3} \text{ s} \end{aligned}$	Correct answer. A2		

Question	Evidence	Evidence contributing to Achievement	Evidence contributing to Achievement with Merit	Evidence contributing to Achievement with Excellence
3(f)(ii)	the least accurate of the data used had 2 sf.	Correct reason. A1		
3(g)	<p>By Kirchhoff's voltage law, when the circuit is completed, the induced voltage in the coil cannot exceed the battery voltage (12 V). As the induced voltage is proportional to the rate at which current is changing, the minimum time taken for the change to be completed is limited by the battery voltage.</p> <p>When the circuit is broken, the coil no longer makes a closed loop with the battery, so the rate of change of current is no longer limited by the battery voltage, and so is much greater, thus the change takes less time to complete.</p> <p>OR</p> <p>The time constant gives a measure of the rate of change of current. For an inductor T is inversely proportional to resistance. When the circuit is complete the resistance is relatively small, so the time constant is large. When the circuit is broken the resistance approaches infinity. The time constant is therefore very small and the current reduces to zero very quickly.</p>	<p><i>One correct and relevant statement – not a repeat of 3(c). A1</i></p>	<p>Valid link made to the time being controlled by the battery at switch on, but not at switch off.</p> <p>OR</p> <p>Link made to time constant being related to higher resistance at turn off compared to turn on.</p> <p>OR</p> <p><i>Much larger voltage at turn off compared to turn on indicates a larger rate of change of current. M1</i></p>	<p>Clear, complete, concise, correct. E1</p>
3(h)	$\frac{V_s}{V_p} = \frac{N_s}{N_p} \Rightarrow V_s = 410 \times \frac{33\,000}{150} = 90\,000$ <p>200 = 90 000 V</p>		<p>Correct answer. M2</p>	

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

2 × M1 + 4 × A1

Achievement with Excellence:

Total of 6 opportunities answered with 1 at Excellence level **and** 1 at Merit level **and** 4 at Achievement level

1 × E1 + 1 × M1 + 4 × A1

Criterion 2

Achievement:

Total of 4 opportunities answered at Achievement (or higher)

4 × A2

Achievement with Merit:

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

3 × M2 + 4 × 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 × E2 + 3 × M2 + 3 × A2

Grade distribution and sufficiency table:

	A		M		E	
1	Units: 4 required SF: 3f(ii) 1f 2a, 2b, 2f, 2h 3a, 3c	5 of 9	2a, 2f 3c, 3g	tot of 6 incl 2M	2f 3g	tot of 6 incl 1M plus 1E
2	1a, 1c, 1e 2c, 2g 3b, 3f(i)	4 of 7	1b, 1d, 1f 2e 3d, 3h	tot of 7 incl 3 M +	1g 2d 3e	tot of 8 incl 3 M plus 2 E