Question	Evidence	1–4 marks	5–6 marks	7–8 marks
3(a)	$v = f\lambda$ $\Rightarrow 99.2 \times \frac{4D}{n} = 127.5 \times \frac{4D}{n+2}$ $99.2(n+2) = 127.5$ $n = 7$ $\Rightarrow 340 = 99.2 \times \frac{4D}{7}$ $D = 6.0\,\text{m}$ An equivalent method is to calculate the respective wavelengths and equate them to each harmonic ($\lambda = \frac{4D}{n}$) and see where the two series converge.	Partially correct mathematical analysis of given problems AND/OR Incomplete discussion of the underlying physics of the LCR resonant circuit OR Correct mathematical analysis of given problems OR Thorough discussion of the underlying physics of the LCR resonant circuit.	(Partially) correct mathematical analysis of given problems AND Reasonably thorough discussion of the underlying physics of the LCR resonant circuit.	Correct mathematical analysis of given problems AND Thorough discussion of the underlying physics of the LCR resonant circuit.
(b)	Doppler Effect – source moving away $f' = f\frac{v_w}{v_w + v_s}$ $v_s = f\frac{v_w}{f'} - v_w$ $v_s = 530 \times \frac{340}{500} - 340$ $v_s = 20.4\ \text{m s}^{-1}$ Assume free fall: $v_f^2 = v_i^2 + 2ad$ $d = \frac{v_f^2 - v_i^2}{2a}$ $d = \frac{20.4^2 - 0}{2 \times 9.80}$ $d = 21\ \text{m}$			

<table>
<tr><th>Question</th><th>Evidence</th><th>1-4 marks</th><th>5-6 marks</th><th>7-8 marks</th></tr>
<tr><td>4(a)(i)</td><td>That the Doppler effect is symmetrical - the gain in frequency heard by the observer B will be the same as the reduction in frequency heard by observer A</td><td rowspan="4">Shows some understanding of the underlying physics.

AND / OR

(partially) correct mathematical solution to given problem.</td><td rowspan="4">A reasonable understanding of the underlying physics.

AND

(partially) correct mathematical solution to given problem.</td><td rowspan="4">Thorough understanding of the underlying physics.

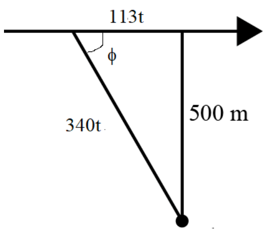
AND

Correct mathematical solution to the given problem.</td></tr>
<tr><td>(ii)</td><td>For A, $f = \frac{f_0 v}{(v + v_s)}$ = 1457/1417 by substitution</td></tr>
<tr><td>(iii)</td><td>The Doppler effect is not symmetrical. If the source travels as fast or faster than the wave speed of the emitted sound, then a forward observer will hear nothing until the source actually reaches the observer. And the sound heard will have "infinite" frequency - it will be a "sonic boom". Waves travelling backwards will still eventually reach the rear observer, just with a reduced frequency - that frequency will never drop to zero, no matter how fast the source moves.</td></tr>
<tr><td>(b)</td><td>All true except the last point, “it is this that gives the orange-red colour.” The Earth does spin to the East and so it is to the East that we see the morning Sun. In both the morning and evening the Sun is low on the horizon and so the Sun appears to be approaching/receding faster than at other times of the day when it is overhead. The light is red-shifted in the evening (because the Sun appears to be moving away, but it would be equally blue shifted in the morning by the same argument. In fact, the velocity (approx 450 ms^{-1}) of the observer, created by the spinning earth is too slow to make a measurable difference.
(Teaching note: The colour of the sunset is caused by shorter wavelength (green-blue) light waves being scattered by atmospheric particles, leaving just the red-orange in the direct line of sight.)</td></tr>
</table>

Assessment Schedule – 2017

Scholarship Physics (93103)

Evidence Statement

Q	Evidence	1-4 marks	5-6 marks	7-8 marks
ONE (a)(i)	Due to the motion of the source, there are compressions and stretching of wavelengths while the velocity remains constant. This leads to a change in frequency. The instantaneous change in frequency means that the plane has been assumed to pass directly through the observer.	Thorough understanding of these applications of physics. OR Partially correct mathematical solution to the given problems. AND / OR Partial understanding of these applications of physics.	(Partially) correct mathematical solution to the given problems. AND / OR Reasonably thorough understanding of these applications of physics.	Correct mathematical solution to the given problems. AND Thorough understanding of these applications of physics.
(ii)	$f'_a = \frac{f\,v_w}{v_w - v_s}$ $1500 = \frac{1000 \times 340}{340 - v_s}$ $f'_b = \frac{f\,v_w}{v_w + v_s}$ $750 = \frac{1000 \times 340}{340 + v_s}$ Substituting gives $= 113.333 \text{ m s}^{-1}$			
(b)	 Component of the plane's velocity at emission point towards observer = $v\cos\phi = 113 \times \frac{113}{340}$ = 37.78 m s^{-1} $f' = \frac{f\,v_w}{v_w - v_s} = 1 \times 10^3 \frac{340}{(340 - 37.78)} = 1.125 \times 10^3$ Hz			
(c)	Vertical force on plane (after the drop) = 4000 g – 3000g = 1000 g Vertical acceleration of plane = $\frac{F}{m} = \frac{1000g}{3000} = \frac{1}{3}g$ Vertical distance moved by plane in 1.5 s = ½ at^2 = 0.5 × 0.33 × 9.81 × 1.5^2 = 3.68 m Vertical distance fallen by pod = 0.5 × 9.81 × 1.5^2 = 11.036 m Vertical separation = 14.72 m.			

Assessment Schedule – 2014

Scholarship Physics (93103)

Evidence Statement

Q	Evidence	1–4 marks	5–6 marks	7–8 marks
ONE (a)	$E = \mathrm{h}f$ $14.0\text{ keV} = 14.0 \times 10^{3} \times 1.6 \times 10^{-19} = 2.24 \times 10^{-15}\text{ J}$ $f = \frac{E}{\mathrm{h}} = \frac{2.24 \times 10^{-15}\text{ J}}{6.63 \times 10^{-34}\text{ J s}} = 3.38 \times 10^{18}\text{ Hz}$	Thorough understanding of these applications of physics. OR Partially correct mathematical solution to the given problems. AND / OR Partial understanding of these applications of physics.	(Partially) correct mathematical solution to the given problems. AND / OR Reasonably thorough understanding of these applications of physics.	Correct mathematical solution to the given problems. AND Thorough understanding of these applications of physics.
(b)	$\Delta E = \frac{Eg\Delta x}{\mathrm{c}^2}$ $\text{So, } \mathrm{h}(f + \Delta f) = E + \Delta E$ $\text{So, } \frac{\Delta f}{f} = \frac{\frac{\Delta E}{\mathrm{h}}}{\frac{E}{\mathrm{h}}} = \frac{\Delta E}{E}$ $= \frac{g\Delta x}{\mathrm{c}^2} = \frac{9.81 \times 22.5}{(3 \times 10^{8})^2}$ $= 2.45 \times 10^{-15}$			
(c)	The frequency of the incident gamma rays can be reduced by the movement of the source or detector away from each other. Such movement apart will result in an increase in the wavelength of the waves which, because the wave velocity is constant, will cause the frequency to decrease the necessary amount.			
(d)	$f' = f\left(1 + \frac{v_\mathrm{s}}{2v_\mathrm{w}}\right)^2$ $\Delta f = f' - f = f\left(1 + \frac{v_\mathrm{s}}{2v_\mathrm{w}}\right)^2 - f$ $= f\left(1 + \frac{v_\mathrm{s}}{v_\mathrm{w}} + \left(\frac{v_\mathrm{s}}{2v_\mathrm{w}}\right)^2 - 1\right)$ $= f\left(\frac{v_\mathrm{s}}{v_\mathrm{w}} + \left(\frac{v_\mathrm{s}}{2v_\mathrm{w}}\right)^2\right)$ $= f\left(\frac{v_\mathrm{s}}{v_\mathrm{w}}\right)$, to first order (ie if $\frac{v_\mathrm{s}}{v_\mathrm{w}} << 1$) Given that $v_\mathrm{w} = 3 \times 10^{8}\text{ m s}^{-1}$, this is a good assumption. v_s would be at most ~100 m s^{-1} in lab situation.			

Q	Evidence	1-4 marks	5-6 marks	7-8 marks
TWO (a)(i)	Operating resistance of bulb $= \dfrac{V^2}{W} = \dfrac{120^2}{75} = 192\ \Omega$ Put a 192 Ω resistor in series with the bulb. The voltage drop across each will be 240 /2 = 120 V (the required operating voltage for the bulb) The power drawn by this configuration will be $240 \times \dfrac{75}{120} = 150\text{ W}$	Thorough understanding of these applications of physics. OR Partially correct mathematical solution to the given problems. AND / OR Partial understanding of these applications of physics.	(Partially) correct mathematical solution to the given problems. AND / OR Reasonably thorough understanding of these applications of physics.	Correct mathematical solution to the given problems. AND Thorough understanding of these applications of physics
(ii)	With the inductor (L) , the V_R will be 90° out of step with V_L. $V_S^2 = V_L^2 + V_R^2$ $V_L = \sqrt{240^2 - 120^2} = 120\sqrt{3}$ $X_L = \dfrac{V_L}{I} = \dfrac{120\sqrt{3}}{\left(\dfrac{75}{120}\right)} = 192\sqrt{3}$ $L = \dfrac{X_L}{w} = \dfrac{192\sqrt{3}}{2\pi \times 50} = 1.06\text{ H}$ Power drawn is just the 75 W dissipated by the bulb. The inductor dissipates no power.			
(b)	The AC in the coil creates a strong and fluctuating magnetic field around the iron core. This moving magnetism induces a current in the aluminium ring (an eddy current). The eddy current produces its own magnetic field, which acts in the opposite direction (is repelled by) the coil's magnetism. The repulsive force between the two can be larger than the force of gravity on the ring so the ring is moved away from the coil until it reaches a distance at which the upward magnetic repulsive force is equal to the downward gravitational force.			
(c)	Make the coil "non-inductive" by reversing the direction of the windings after half have been completed in one direction. Reverse the direction of half the windings so that the amount of clockwise current is balanced by an equal amount of anticlockwise current.			
(d)	The glue must be non conducting (and must be permeable to magnetic fields). The core must be laminated to reduce the induction of eddy currents, which would both waste a lot of energy and produce a lot of potentially damaging heat.			

FOUR (a)	$d \sin \theta = n \lambda$ $d = \dfrac{587.563 \times 10^{-9}}{\sin 20.6426}$ $d = 1.66 \times 10^{-6}$ m Number of lines per cm = 6 000	Shows some understanding of the underlying physics. AND/OR (Partially) correct mathematical solution to given problem.	A reasonable understanding of the underlying physics. AND (Partially) correct mathematical solution to given problem.	Thorough understanding of the underlying physics. AND Correct mathematical solution to the given problem.
(b)	The stellar wavelength is longer than the lab wavelength. Sources moving away from an observer have the wavelength of any emitted radiation increased; we say "red shifted" (since red is the largest observable visible wavelength). So the two wavelengths are different because the stellar source is moving radially away from the Earth.			
(c)	$f' = f\left(\dfrac{v_w}{v_w + v_s}\right)$ $\dfrac{f'}{c} = \dfrac{f}{c}\left(\dfrac{v_w}{v_w + v_s}\right) \Rightarrow \dfrac{1}{\lambda'} = \dfrac{1}{\lambda}\left(\dfrac{v_w}{v_w + v_s}\right)$ $\Rightarrow \lambda' = \lambda\left(\dfrac{v_w + v_s}{v_w}\right)$ $\Delta\lambda = \lambda' - \lambda = \lambda\left(\dfrac{v_w + v_s}{v_w} - 1\right) = \lambda\left(\dfrac{v_s}{v_w}\right)$ $\dfrac{\Delta\lambda}{\lambda} = \dfrac{v_s}{v_w} = \dfrac{v_s}{c}$			
(d)	A reasonable approximation would be to find the average wavelength from the star 0.5 × (587.67 + 587.60) nm = 587.635 gives $\Delta\lambda = 0.072$ nm $\dfrac{v_{\text{source}}}{\text{c}} = \dfrac{\Delta\lambda}{\lambda} = \dfrac{0.072 \times 10^{-9}}{587.563 \times 10^{-9}}$ $\Rightarrow v_{\text{source}} = 36.7 \text{ km s}^{-1}$ Assumption(s): The source is going directly (radially) away from the Earth. Otherwise the answer given would be the radial component of the helium source's velocity. Relativistic effects can be ignored.			
(e)	Possible mechanisms include but are not limited to: • Doppler broadening, due to thermal motion of the emitting atoms. Becomes larger at higher temperatures (greater atomic velocities). • Doppler broadening, due to stellar rotation. • Broadening caused by energy level shifts due to pressure, electric fields, magnetic fields.			

Question	Type 1 (explanatory) or Type 2 (problem)	B Evidence	A Evidence
2(i)	1	The frequency of the reflected wave would be greater than the frequency of the incident wave. This is because as the blood moves towards the detector the reflected wavefronts will become closer together.	The frequency of the reflected wave would be greater than the frequency of the incident wave. This is because as the blood moves towards the detector the reflected wavefronts will become closer together. The velocity of the ultrasound is unchanged so it will have a higher frequency.
2(ii)	2		Student 1 has derived the correct equation. Student 2 is incorrect because as the blood velocity tends to zero the Doppler shift tends to infinity or as the blood velocity increases the Doppler shift decreases. Student 3 is incorrect because we would expect maximum Doppler shift when the blood is moving towards or away from the detector and zero shift when the blood is moving perpendicularly to the sound wave.

Question	Type 1 (explanatory) or Type 2 (problem)	B Evidence	A Evidence
			This equation would cause the effect to be the opposite way round.
2(iii)	2	$v = \frac{\Delta fc}{2f\cos\theta} = \frac{3100 \times 1.5 \times 10^3}{2 \times 5 \times 10^6 \cos 30^\circ} = 54\,\text{cm s}^{-1}$ Candidates who have selected student 2's equation as correct will obtain a huge velocity. They should realise that this is unrealistic and correct their error by using one of the other equations. Candidates who have selected Student 3's equation will obtain a similar (but incorrect) answer. Their mistake is not obvious, so award credit for continuity.	
2(iv)	1		Explanation must include the key points below: This method measures the magnitude of the **change** in frequency. There is no indication of whether the change in frequency is positive or negative so therefore there is no indication of whether the blood is flowing towards or away from the detector. Another possible answer could include a discussion of effective scattering volumes overlapping each other.
3(i)	1	The sources must have: 1) the same wavelength 2) fixed phase difference or coherent	The sources must have: 1) the same wavelength 2) fixed phase difference or coherent 3) a separation (d) greater than the wavelength 4) comparable amplitudes