Physics

Subject Code: PHY315109

2009 Assessment Report

The examining panel considered the 2009 paper to be excellent in that there was plenty of scope for the weaker candidates to display their Physics knowledge whilst presenting some challenging questions that allowed the more capable candidates to demonstrate their abilities. As an assessment tool it was at an appropriate standard, provided a good distribution of marks and reflected the spirit of the syllabus. As shown by the range of cut-offs below, Criteria 5 and 7 were more straightforward than the other criteria.

Overall, the standard of candidates' responses were generally good. There appeared to be more very good scripts this year particularly in Criterion 5 and 7. Unfortunately there were also a considerable number of very poor and incomplete booklets and there were many more 't' ratings awarded externally than internally. Typically there were 65 external 't' ratings compared with 20 given internally.

The perennial problems of algebraic manipulation and forgetting to include directions for vectors were present. Candidates, on the whole, did present their answers to an appropriate number of significant figures. The standard of expression in written answers was good but poor spelling was, as usual, evident.

The answers to the 2009 paper have been included in this report. They are in *italics*, following the marker's comment for each question. The marker's comments and points that should be included in an answer have been merged in a few questions (eg in Question 1 parts b) and c)). There is often more than one way to arrive at a correct answer. It is hoped that combining the answers with the comments will give future candidates a better ‘feel’ for how the Physics paper is marked and the detail required in responses.

The marks (/45) required for each rating in each criterion are given in the table below.

Criterion \ Award	A	B	C
5	38	29	20
6	32	25	16
7	35	29	20
8	30	24	16

Part 1 – Criterion 5

Question 1

Parts a) and b) were only marked as correct if the working out (finding and demonstrating the area under the graph) was included.

a) Nearly all candidates recognised the work done as being equal to the area under the graph. However, many merely presented .006 x 200 to get the required result. A correct answer identified the two discrete areas under the graph (triangle and rectangle) such that:

$W = (0.5 \times 200 \times 6 \times 10^{-3}) + (200 \times 3 \times 10^{-3}) = 0.6 + 0.6 = 1.2\ J$

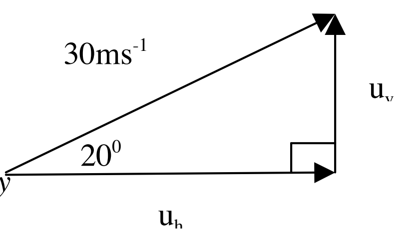
b) The correct answer was determined by finding the area under the graph. Candidates who were successful in Part a) were nearly always successful in Part b). Common wrong answers were 0.72 J or 1.08 J.

c) Full marks were awarded for the inclusion of a discussion of the transfer from kinetic energy to potential energy and back to kinetic energy with the dissipation of some useful energy through heat, sound etc. Many candidates included one or the other and so gained half marks for their incomplete response. Some candidates also included numerical values based on the graphs.

Question 2

a) Very well done. Common mistakes were not using vector analysis to find and use the vertical component of the initial velocity, and using a value of 30 m s^{-1} instead. The use of range finding formulae resulted in half marks being awarded.

$u_v = 30\sin 20 = 10.26\ m\ s^{-1}$ □
$v_v = u_v + at v_v = u_v + (-9.81)t$
$0 = 10.26 - 9.81t$
$t = 1.046\ sec$



This is time to the top of the arc, so the return journey will take 1.046 x 2 = 2.09 secs.

b) Very well done.

$U_h = 30\cos 20 = 28.19\ m\ s^{-1}$
$s = U_h \times t = 28.19 \times 2.09 = 58.92\ m$

c) Generally well done. It can be completed in three lines by finding the time it is in the air to reach 50 m and then using $s = ut + 1/2\ at^2$. A common mistake using this method was failing to realise that **u** and **a** are in opposite directions, and must have an opposite sign. Many candidates successfully found the highest point and subtracted the height that the ball dropped.

Time for ball to travel 50m horizontally:

$T = s / U_h = 50 / 28.19 = 1.77$ *secs*
$s = U_v + 1/2at^2 = 10.26 \times 1.77 + 1/2 \times (-9.81) \times (1.77)^2$
$= 18.16 - 15.37 = 2.79$ *m*

Question 3

a) Adequately answered. One mark was deducted for not including the sign. An answer of 15 m s^{-1} was a common mistake.

Change in velocity = final velocity – initial velocity $= 45\ m\ s^{-1} \downarrow - 30\ m\ s^{-1} \uparrow$
$= 45\ m\ s^{-1} \downarrow + 30\ m\ s^{-1} \downarrow = 75\ m\ s^{-1} \downarrow$

b) Well done.

$F = m\triangle v/\triangle t = 0.16 \times 75/1.0 \times 10^{-3} = 12000\ N \downarrow$ *(in direction of change in velocity)*

c) Generally well done. A lot of candidates achieved full marks for this part.

Momentum before and after collision is conserved, so:

$m_{ball\ before} \times v_{ball\ before} + m_{bat\ before} \times v_{bat\ before} = m_{ball\ after} \times v_{ball\ after} + m_{bat\ after} \times v_{bat\ after}$
$0.16 \times 30 \uparrow + 1.2 \times 39 \downarrow = 0.16 \times 45 \downarrow + 1.2 \times v_{bat\ after}$
$0.16 \times 30 \uparrow - 1.2 \times 39 \uparrow = -0.16 \times 45 \uparrow + 1.2 \times v_{bat\ after}$
$4.8 \uparrow - 42 \uparrow = -7.2 \uparrow + 1.2 \times v_{bat\ after}$
$-34.8 \uparrow = 1.2 \times v_{bat\ after}$
$-29 \uparrow = v_{bat\ after}$
$29\ m\ s^{-1} \downarrow = v_{bat\ after}$

Alternatively candidates achieved full marks by considering the change in velocity

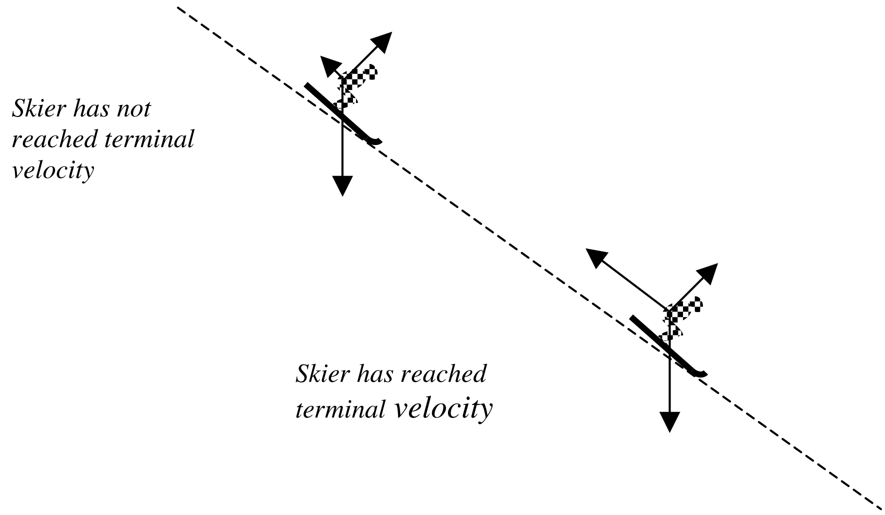
$F = m\triangle v/\triangle t = 1.2 \times (39 - 29)/1.0 \times 10^{-3} = 12000\ N \uparrow$ and calculating the final velocity.

d) i. Well done. Candidates who got the sign wrong in Part b) recognised that the sign in this part was in the opposite direction, and put south; they were not penalised. Candidates were required to **calculate** the force, and so were penalised if they merely relied on saying it was a Newton's Third Law pair with the force on the ball from Part b).

ii. Well done. Merely stating Newton's Third Law garnered no mark. Candidates had to explicitly state the connection with the bat and ball.

Question 4

a) i. Most candidates got some marks for this question. The most common mistakes were overcomplicating the diagram by adding all sorts of extra forces, forces in the wrong direction and forces not being of the correct relative size across the two diagrams.



ii. Generally well answered. Most candidates understood that there was no resultant force when the skier was moving at terminal velocity.

There is a resultant force down the slope in the first diagram. There is no resultant force in the second diagram.

b) Generally well answered, with most candidates choosing the forces approach rather than the energy approach. Some candidates were determined to use W = Fs**Cos**θ, using 30^o as a value for θ. This led to all sorts of difficulties in answering the question.

Work done = work against gravity + work against friction.

$$W = mgh + Fs = (80 \times 9.81 \times 50) + (108 \times 100) = 5 \times 10^4\ J$$

Or *Total force applied by the rope up the slope = mgsinθ + Fs*

$$F = (80 \times 9.81 \times 0.5) + 108 = 500\ N$$
$$W = Fs = 500 \times 100 = 5 \times 10^4\ J$$

c) Very well answered.

Time = distance / velocity = 100/1 = 100 s
$P = W/t = 5 \times 10^4/100 = 500\ W$.

Question 5

ai) Very well answered, the only common mistake was forgetting to square the radius.

$F = \frac{Gm_1m_2}{r^2} \Rightarrow 1.47 \times 10^{-7} = \frac{G \times 0.73 \times 158}{(0.23^2)} \Rightarrow G = 6.74 \times 10^{-11}\ m^3\,kg^{-1}\,s^{-2}$

aii) Very well answered, the only common mistake was forgetting to square the radius.

$g = \frac{Gm}{r^2} \Rightarrow 9.81 = \frac{6.74 \times 10^{-11} \times m}{(6.37 \times 10^6)^2} \Rightarrow m = 5.91 \times 10^{24}\ kg$

bi) Very well answered, the only common mistake was forgetting to square the radius.

$a_c = \frac{4\pi^2 r}{T^2} \Rightarrow a_c = \frac{4\pi^2 \times 3.8 \times 10^8}{(2.26 \times 10^6)^2} \Rightarrow a_c = 2.9 \times 10^{-3}\ m\,s^{-2}$

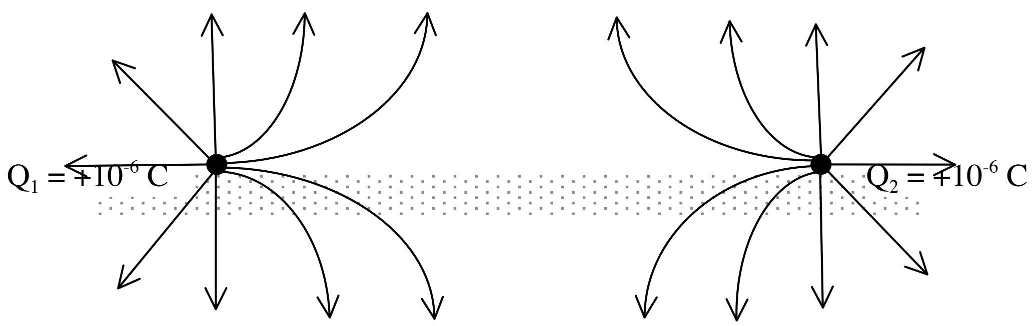
bii) Quite well answered. Forgetting to square the r values was again the most common error.

Constant $= ar^2$
For the surface: $k = 9.8 \times (6.37 \times 10^6)^2 = 3.98 \times 10^{14}$
For the moon: $k = 2.9 \times 10^{-3} \times (3.8 \times 10^8)^2 = 4.18 \times 10^{14}$
The two values are very similar and therefore consistent with the inverse square law.

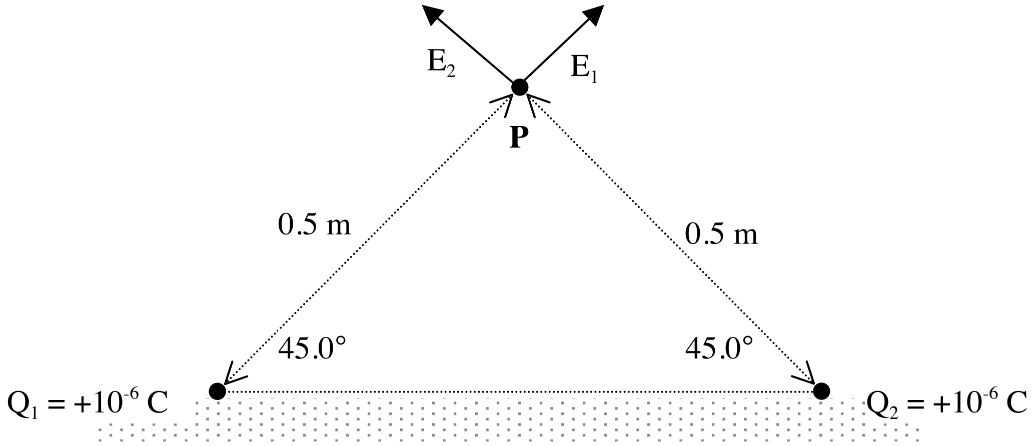
Part 2 – Criterion 6

Question 6

a) Generally well answered. Some candidates, however, did not clearly show the **resultant** field, but rather just the field lines around a point charge; a few drew concentric circles around the point charges. To gain full marks the correct resultant field pattern was required (1 mark) with the arrows in the correct direction (1 mark).



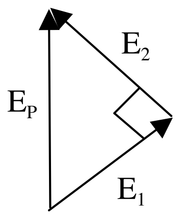
b) Vectors must be drawn and labeled correctly (1 mark). Some candidates drew the vectors along the lines QP with arrowheads pointing at P; this gained half marks.



c) Generally well answered.

$$E = \frac{KQ}{r^2} = \frac{(9\times10^9)\times10^{-6}}{0.5^2} = 36 \text{ kV m}^{-1}$$

d) Well attempted overall. Some candidates used the charge instead of electric field strength and some candidates struggled to rearrange Pythagoras' equation. Many forgot to state the direction, even though the question specifically asked for it! Correct vector diagram earned a half mark, the magnitude of field strength 1 mark and the direction the last half mark.



$$E_p{}^2 = E_1{}^2 + E_2{}^2$$

$$\therefore E_p = \sqrt{36000^2 + 36000^2} = 5.09 \times 10^4 \text{ Vm}^{-1}$$

Vertically upwards from surface of moon

e) Well answered. A number of candidates used the field strength due to one charge rather than the resultant field.
Marking scheme:– correct equation (1 mark), correct substitution of variables (half mark) and correct calculation (half mark).

As P is stationary $F_E = F_g$ *in magnitude*

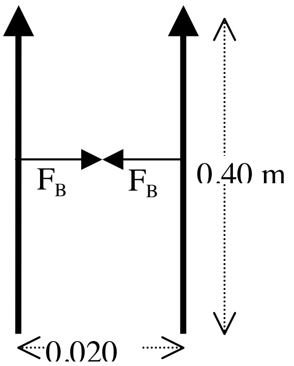
$$\therefore m = \frac{E_P\, q}{g} = \frac{(5.09\times10^4)\times10^{-6}}{1.6} = 3.18 \times 10^{-2} \text{ kg}$$

f) Well answered. Some candidates did not know how to put '10^{-6}' into their calculator; if working was shown they gained half a mark.

$$\text{no. of electrons} = \frac{\text{total charge}}{\text{charge on } 1e^-} = \frac{10^{-6}}{1.6 \times 10^{-19}} = 6.25 \times 10^{12} \ \textit{electrons}$$

Question 7

a) Well answered by most candidates with a small number drawing magnetic field lines rather than force vectors.
Marking scheme:– arrows showing that wires would attract 1 mark.



b) Well answered by most candidates. Note that a direction was not required as this was already assessed in Part (a).
Marking scheme:– correct equation (half mark), correct substitution and answer (half mark).

$$F_B = \frac{kI_1 I_2 l}{r} = \frac{(2\times10^{7})\times10\times10\times0.4}{2\times10^{-2}} = 4 \times 10^{-4} \text{ N}$$

c) A large number of candidates failed to realize that the horizontal component had no effect and proceeded to find the resultant field and angle before applying the equation. These candidates still gained marks as above minus the mark for correct use of equation. There is no force due to the horizontal component of the Earth's magnetic field as this runs parallel to the wires i.e. $\sin\theta = 0$
Marking scheme:– correct use of equation (1 mark), correct numerical answer (half mark) and correct direction (half mark)

$$F_B = BIl\sin\theta = (3\times10^{-5})\times10\times0.4\sin 90 = 1.2\times10^{-4} \text{ N} \quad \text{East}$$

Question 8

a) Generally well answered, with candidates finding Part (ii) easier than Part (i). A number forgot to multiply by 2 for the charge on the ion.
Marking scheme:– correct use of equation (half mark), correct substitution and answer (half mark).

(i) *5000 × 2 = 10 000 eV = 10 keV*

(ii) $E_f = Vq = 5000 \times 2 \times (1.6\times10^{-19}) = 1.6\times10^{-15}$ J

b) Candidates did not lose marks for using the wrong energy value in Part b) as long as it corresponded to their answer in Part a(ii).

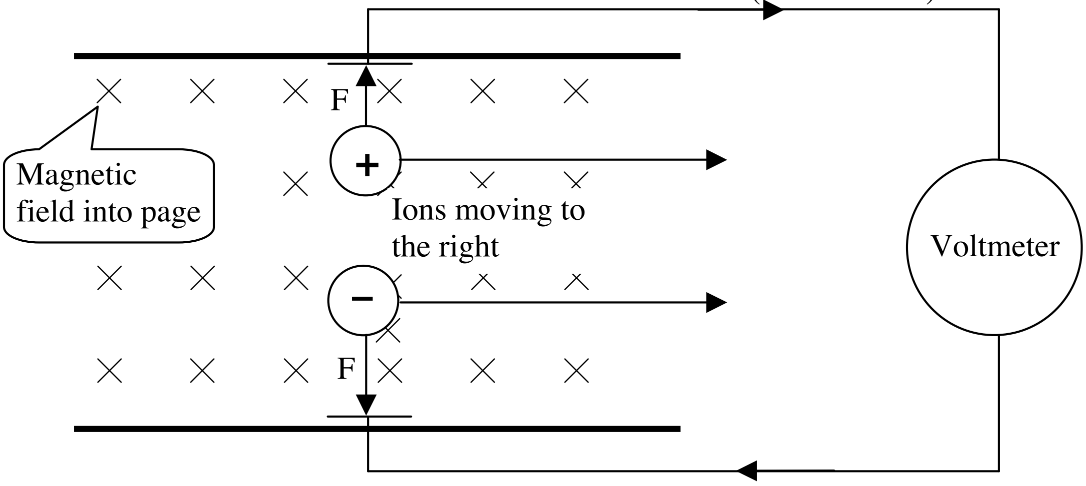
$$E_f = \frac{1}{2}mv^2 \qquad \therefore v = \sqrt{\frac{2E_f}{m}} = \sqrt{\frac{2\times(1.6\times10^{-15})}{2.67\times10^{-26}}} = 3.46\times10^5 \text{ ms}^{-1}$$

c) Well attempted by most candidates.
Marking scheme:– correct selection of equation (1 mark), correct substitution (1 mark), correct direction stated (1 mark).

$$F_E = Eq = \frac{Vq}{d} = \frac{E_f}{d} = \frac{1.6\times10^{-15}}{2\times10^{-2}} = 8\times10^{-14} \text{ N} \qquad \text{Towards the -ve plate}$$

Question 9

a) Most candidates got the direction of the forces correct but many got the induced current direction wrong.



b) Correct selection of equation (half mark), correct substitution (half mark).

$$emf = Blv\sin\theta$$

$$\therefore v = \frac{emf}{Bl\sin\theta} = \frac{30\times10^{-3}}{0.1\times(200\times10^{-3})\times\sin 90} = 1.5 \text{ ms}^{-1}$$

c) Poorly answered. Many candidates seemed to think this was a Lenz's Law question or talked about the ions.

If the pipe is made from a conducting material the voltmeter will be 'shorted out' therefore not allowing an emf to be measured and velocity to be calculated.

Question 10

a) Most candidates realised that using the formula r = mv/qB was the key to answering this question and then translating it to B = mv/qr. Substituting values gives the required 0.24T. Another minority approach was to use $F_c = mv^2/r$ and then F =qvB, pre-empting the next part of the question. Errors included B = kI/r and Emf = vlB where $E = 1x10^6$, which is incorrect.

b) The straightforward use of F= qvB meant most candidates obtained 5.3×10^{-13} N. Errors were usually powers of ten due to poor tracking or misuse of the calculator.

c) Many candidates correctly gave a larger force for B by arguing that the circle is smaller, so the necessary force is larger for all other values being the same. A better argument can be made that the field is stronger as the lines are closer thus the force on the charge with the same speed is larger as F = qvB.

d) Candidates were required to recognise that the forces on A and B are perpendicular to both the field lines and the velocities. The force on A is 'vertically up' the diagram while that on B is larger and slightly pointing to the left. Few picked up on the difference in size but the examiner gave full marks to those who only showed the directions of the magnetic forces. Most candidates only received part marks and many failed as they had vectors everywhere!

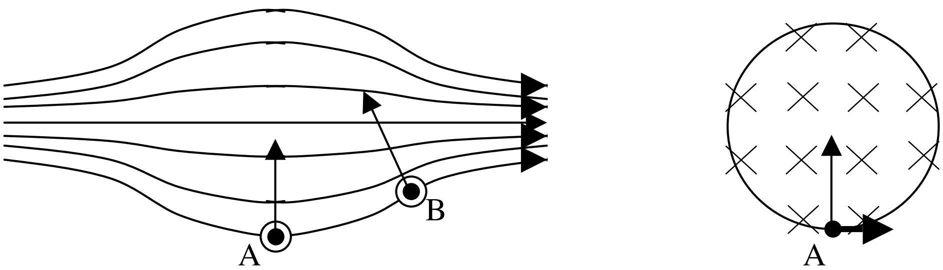
e) It was necessary to recognise the direction of the field had changed so the force has an inward component to the left leading to the containment. This directly related to the correct diagram for d).

a) *r = mv/qB*
so $B = mv/qr = 1.67 \times 10^{-27} \times 1.38 \times 10^{7} / 0.60 \times 1.6 \times 10^{-19} = 0.24$ *T*

b) $F = qvB = 1.6 \times 10^{-19} \times 1.38 \times 10^{7} \times 0.24 = 5.3 \times 10^{-13}$ *N*

c) *The magnetic field strength is larger near the ends as shown by the field lines being closer so, as the speed remains the same, the force acting is larger.*

d)



e) *the force on B has an inward component so it will drift back to the left.*

Question 11

a) Generally this part was poorly done with few candidates realising the need to extrapolate back to vertical axis to get the error in distance.

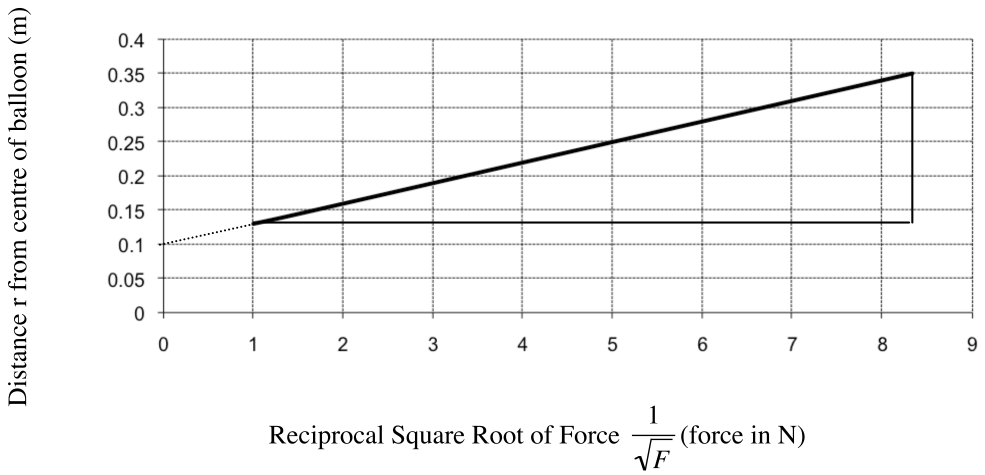
b) Many candidates arrived at the wrong units and a mark was taken off at this point. The gradient value was generally correctly arrived at.

c) The charge on the balloon was poorly calculated, with most candidates taking a point from the curve and attempting to use it to get a charge value. Some credit was given for this approach. Many errors were made during the algebraic processes to arrive at this point. Few candidates correctly applied the gradient calculated in the previous part to obtain the proper charge.

d) The gradient calculation was generally poorly translated into the correct SI units because of a failure to recognise the 'microcoulombs' of the vertical axis and/or not converting minutes to seconds. A number also failed to note that the gradient was a negative value.

e) Many recognised that the gradient represented the rate of loss of charge from the balloon as it slowly discharged.

a) Extrapolating back, the distance from the centre is 0.1 m. (The way the graph is set up, an error in the radial distance will show as not passing through the origin.)



b) Gradient = (0.35 - 0.13)/7.35 = 0.03 m $N^{1/2}$

c) The equation $r = \sqrt{\frac{kq_1q_2}{F}}$ *can be written as* $r = \sqrt{kq_1q_2}\, x \frac{1}{\sqrt{F}}$ *so the gradient of the graph is* $\sqrt{kq_1q_2}$ *= 0.03.*

Thus, $kq_1q_2 = 9 \times 10^{-4}$, $q_1 = 9 \times 10^{-4} / (9 \times 10^{9} \times 10^{-7}) = 1\ \mu C$

d) *Gradient* = $\dfrac{-0.83\times10^{-6}}{50\times60}$ = *-2.77* x *10*$^{-10}$ *C s*$^{-1}$ *or A*

e) *The gradient is the discharge current from the balloon to the atmosphere at 20 s*

Part 3 – Criterion 7

Question 12

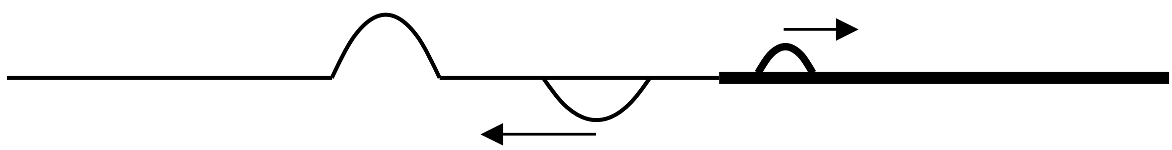
a) A common error was not recognising that the frequency was constant. A number of candidates incorrectly measured amplitude as being trough to peak.

	Light string	**Heavy string**
Frequency ***(2 marks)***	10 Hz	10 Hz
Amplitude ***(1 marks)***	0.2 m	0.14 m
Wavelength ***(1marks)***	2.0 m	1.0 m
Speed of wave ***(2 marks)***	v = fl = 20 m s^{-1}	v = fl = 10 m s^{-1}

Full marks were awarded to candidates who were able to reasonably show each of the following:

- the correct phase of the pulse,
- a reduction in amplitude of both pulses,
- the same wavelength in reflected pulse,
- reduced (by a half) in the transmitted pulse,
- some indication of the direction/velocity of each pulse.

A number of candidates did not consider conservation of energy in the amplitudes.

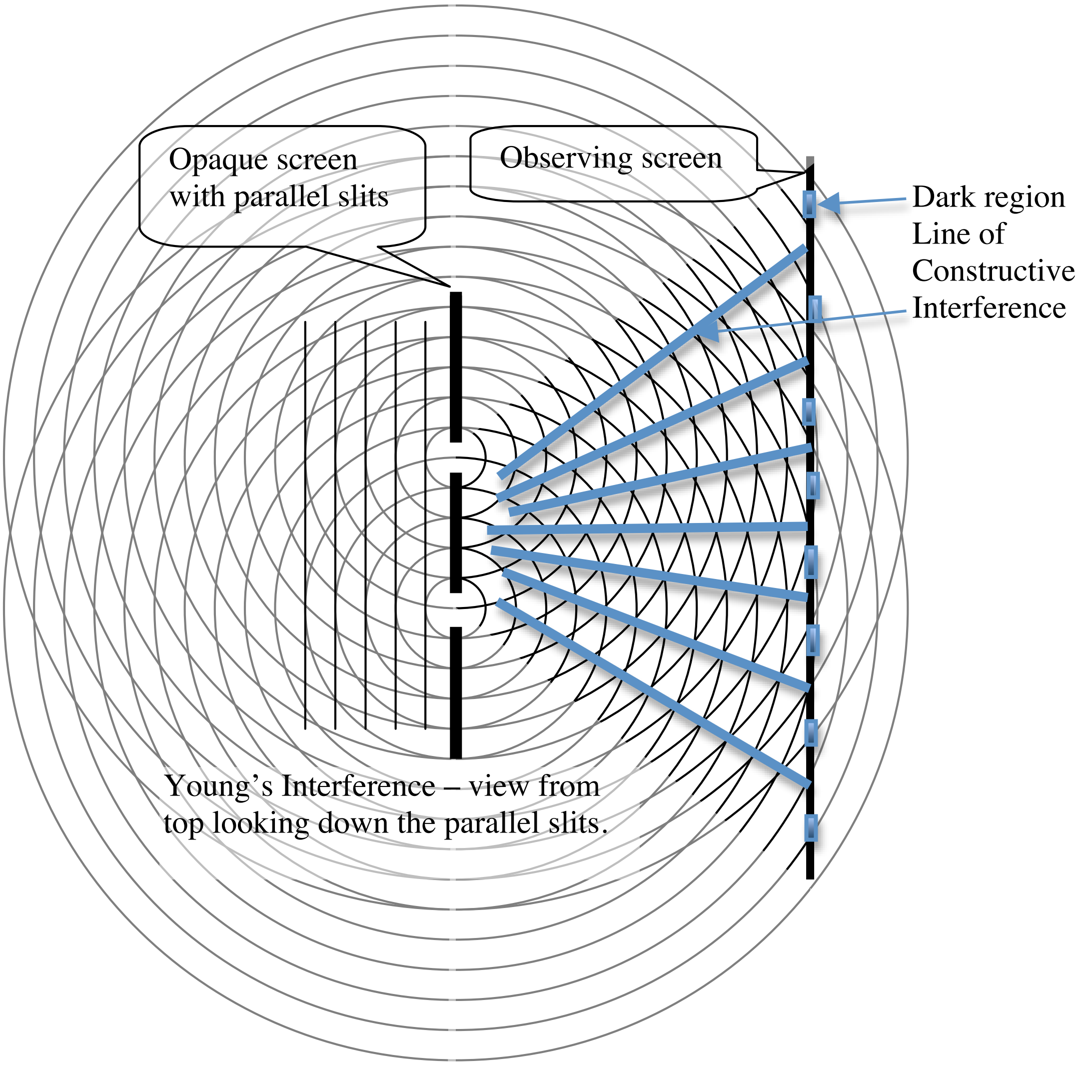


Question 13

a) Well done. Some common calculator issues and incorrectly converting prefixes gave wrong answers. Interestingly, a number of candidates incorrectly used the formula to find the distance between BRIGHT and DARK regions.

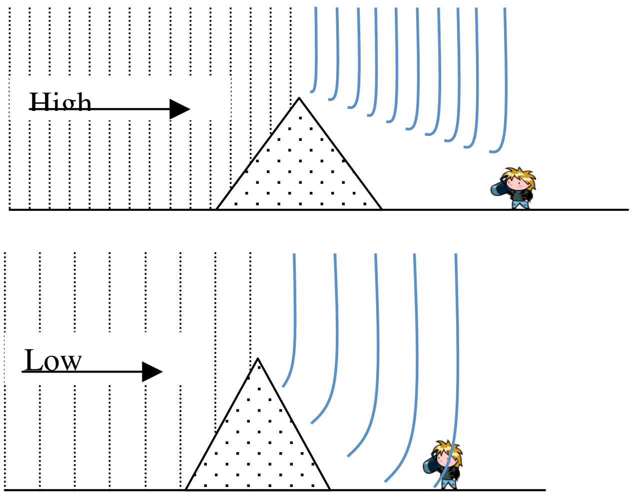
W = xl/d = (0.40 m x *500* x *10*$^{-9}$ *m) / 0.200* x *10*$^{-3}$ *m = 1.0* x *10*$^{-3}$ *m = 1.0 mm*

b) Part i) was well done by most candidates. In Part ii) a common error was the labelling of alternative lines of constructive interference as DARK regions.



Question 14

a) Candidates often interpreted this question as relating to sound waves rather than to radio waves. A large proportion of candidates haphazardly described diffraction. Huygen’s principle was occasionally applied very well. A common incomplete answer was ‘the waves bent around the hill’.

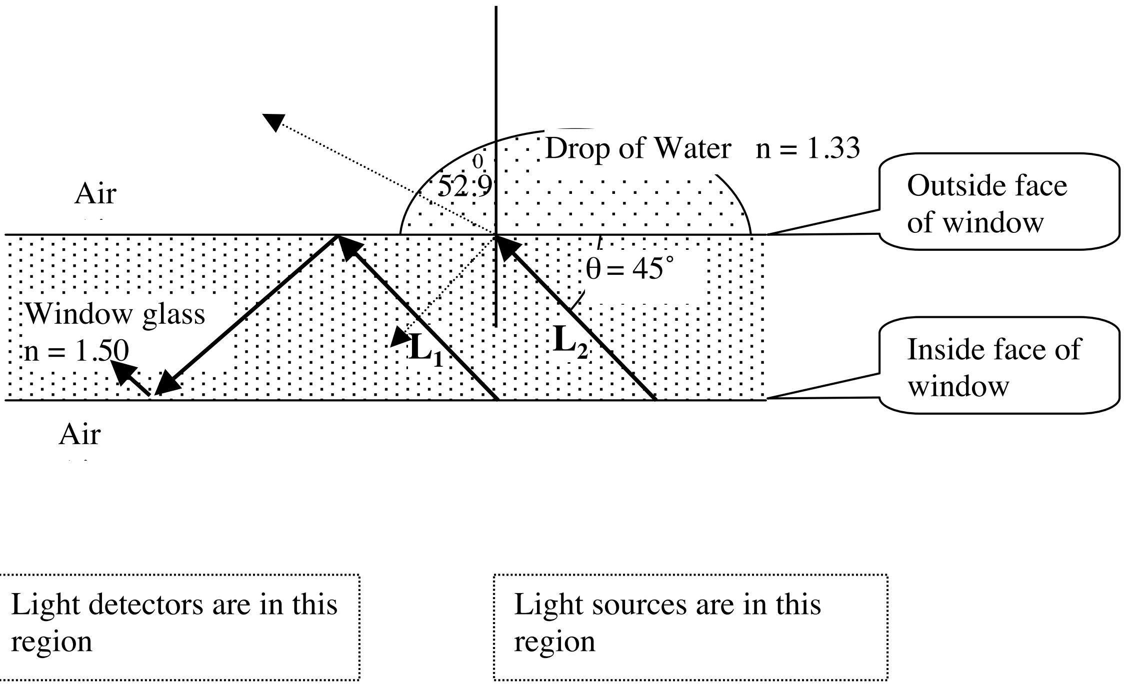


b) Not well done. Many candidates were unable to clearly show diffraction. The confusion between refraction and diffraction was common with diagrams often showing refracted wave fronts. Few candidates correctly showed the high frequency signal diffracting less and some creative and incorrect attempts were made to indicate less wave fronts at the person.

Question 15

a) Carelessly answered by many candidates. Proofs that started from Snell's Law were needed for full marks.

b) The next sections were flawed as what was asked for was not possible. The best answer is shown below and this was awarded bonus marks. No candidates commented that it was not possible to get the beam into the glass from air at 45º. Most candidates took the question at face value but few could get the rays going in the correct direction. The most common error was to show a ray parallel to the top surface of the glass. Due to the error in the question, the marking examiner gave credit for any reasonable attempts.



c) This section was well done. Taken at face value, the expected answer was that the light intensity would be reduced due to raindrops allowing light to escape through the glass water interface because 45º was below the critical angle. Any answer that fitted in with decisions made in section (c) and well explained was given credit.

d) Well done. The fact that IR is invisible was the appropriate response for this section.

Question 16

This question was well done. Unfortunately a number of candidates had no idea about polarization.

a) The advantage of polarizing sunglasses is that they are able to preferentially absorb glare as it is polarized. As a consequence wearers can see past the surface of water. This is in contrast to normal sunglasses, which only reduce the intensity of all light falling onto them.

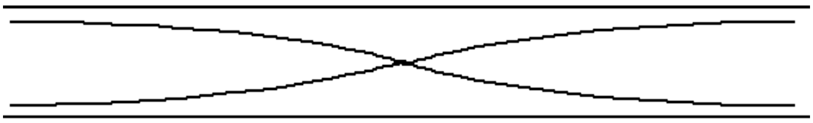
b) *The light from some sections of the sky is polarized in the scattering process. So by looking at the sky through the Polaroid sunglasses and rotating them, sections of the sky will be seen to change brightness. With normal sunglasses this will not occur.*

Question 17

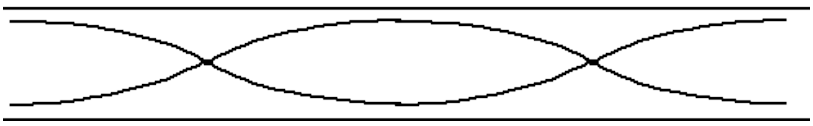
Part a) was well answered but the more difficult Part b) was not. A common misconception was that the vibrating wave in the bat gave the energy to the ball so it should be hit at the antinode at the 25 cm point. The few candidates that said the node at 45 cm was best as the bat at this point is travelling faster, so it will give the ball more energy, were awarded a bonus mark

a) i)

Fundamental



First overtone



(ii) 2 m
(iii) f = v/λ = 340\2 = 170 hz

b) *The best positions to hit the ball were at the nodes (9 cm or 45 cm) as at these point's an applied force to the bat will not start the bat vibrating in the manner shown. Therefore no energy is used to vibrate the bat so more energy is available for the ball (conservation of energy).*

Part 4 – Criterion 8

Question 18

a) This question was well answered, although some candidates started with 656 nm and used the calculated value of energy to find the corresponding energy levels. This is not a preferred method as the 656 nm is an estimate, not an exact value.

$$\Delta E = 24.74 - 21.72 \ = 3.02 \times 10^{-19}\,J$$

as $E = hf$ and $c = f\lambda$ then $\lambda = \dfrac{hf}{\Delta E} = \dfrac{(6.63 \times 10^{-34})(3 \times 10^{8})}{(3.02 \times 10^{-19})} = 658\ nm$

b) This question was generally well done. Some candidates only calculated one value, others thought that the electron was jumping up not down (eg 1→3), others referred to shell number 1 as zero.

Using $E = \frac{hf}{\lambda}$ *for n = 495.9 nm then* $E = \frac{(6.63\times10^{-34})(3\times10^{8})}{(495.9\times10^{-9})} = 4.01\times10^{-19}J$

this is a jump from 3 → 1

Using $E = \frac{hf}{\lambda}$ *for n = 500.7 nm then* $E = \frac{(6.63\times10^{-34})(3\times10^{8})}{(500.7\times10^{-9})} = 3.97\times10^{-19}J$

this is a jump from 3 → 2

c) Again this question was well handled but many candidates failed to compare the two graphs and instead provided an assessment of the result of temperature increase for each graph.

Comparing the two graphs, as temperature increases the relative intensity increases and the wavelength shortens.

d) This question was poorly done. Candidates had problems with

- the word ‘observed’ and thought the emission lines were in the visible spectra.
- not relating the question back to the graphs.
- being unable to calculate the required wavelength to reinforce their answer.

Only very hot stars can emit photons with sufficient energy for short wavelengths. From the graph cold stars (5500℃) do not emit radiation below 190 nm.

$$\lambda = \frac{hf}{\Delta E} = \frac{(6.63\times10^{-34})(3\times10^{8})}{(5\times10^{-18})} = 3.97\times10^{-8} \approx 40nm$$

The wavelength needs to be about 40 nm to ionise oxygen. From the graphs this occurs only in very hot stars (50000℃) as the cold stars do not have photons of sufficient energy.

Question 19

a) Most candidates successfully completed the calculation in this question.

$$E = eV = \frac{hc}{\lambda} \quad then \quad \lambda = \frac{hc}{eV} = \frac{(6.63\times10^{-34})(3\times10^{8})}{(1.6\times10^{-19})(50000)} = 2.486\times10^{-11}m$$

(b) Overall, the candidates' understanding of ‘braking’ X-rays was poor.

Bremsstrahlung, radiation which is emitted when electrons are decelerated or ‘braked’ – brought to rest – in a random manner when they are fired at a solid metal target.

(c) Again it was poorly understood why the energy (intensity of x-ray) spikes occurred. Candidates did not explain how photon energy levels and wavelength could help identify the target metal.

When an energetic incoming electron strikes an atom in the target and knocks out one of its deep-lying (inner) electrons there remains a vacancy in this shell. One of the outer electrons moves to fill the vacancy and in the process the atom emits a characteristic x-ray photon. The spike's wavelength depends on the shell from which the electron fell. The energy levels and wavelength of the 'spikes' are unique to each metal and can therefore be used to identify the target (Moseley's Law).

Question 20

a) Well done, but some candidates were confused between electron volts (eV) and joules (J).

$$E_k = hf - W = \frac{hc}{\lambda} - W = \frac{(6.63\times10^{-34})(3\times10^{8})}{(200\times10^{-9})(1.6\times10^{-19})} - 5$$
$$= 6.215 - 5 = 1.215eV = 1.94\times10^{-19}J$$

b) Candidates did not relate the question in Part (b) to the information contained in Part a), so did not refer to the 200 nm ultra violet light. They did not explain how ultra violet light reached the moon surface (no ozone layer).

The photoelectric effect and the emission of electrons was well understood but most candidates did not realise that the moon dust became positively charged and it was the repulsive electrostatic forces acting between the positive ions and the balancing gravitational force that caused the dust haze.

As the moon has no atmosphere (ozone layer) the UV light is not blocked. The UV light gives the moon dust sufficient energy to emit photoelectrons. This means that the moon dust is now a positive ion. The positively charged moon dust particles repel each other and the positively charged moon's surface. Thus the dust particles are suspended when there is an equilibrium established between the electrostatic repulsion and the gravitational attraction.

Question 21

a) Less than half the candidates gave reasonable answers to this question. Many thought it was the moderator that absorbed excess neutrons.

i. Control rods prevent the chain reaction in a reactor becoming uncontrollable by absorbing a proportion of the product neutrons from fission reactions.

ii. Moderators, such as water or heavy water, are required to slow down the product neutrons so that they may cause further fission reactions. If too fast, neutrons will not cause fission.

(b) Surprisingly, not very well done for very straightforward nuclear equations. There was the expectation that candidates include an antineutrino in equation (ii).

(i) $^{58}_{26}Fe \quad + \quad ^{1}_{0}n \quad \rightarrow \quad ^{29}_{26}Fe$

(ii) $^{29}_{26}Fe \quad \rightarrow \quad ^{59}_{27}Co \quad + \quad ^{0}_{-1}e \quad + \quad \tilde{\nu}$

c) Most candidates were able to apply the appropriate formula and get the correct answer. It did not matter whether base-2 or base-e was used. Watch significant figures and ensure correct units are included.

$A = 3.35 \times 10^{5}\ Bq$

Question 22

a) Well done. Candidates must make sure all working is clearly shown and explained.

Mass defect = 0.0138066 amu
Energy released = 0.0138066 x 931 = 12.85 Mev (or 2.06×10^{-12} *J)*

b) Candidates found this question difficult with few arriving at the correct answer. Many unnecessarily tried to use moles. Candidates should take a couple of moments to check if their answer makes sense. Answers ranged from 10^{-20} kg to 10^{59} kg. This latter number probably amounts to more mass than there is in the universe!

1000 MW = 1000 MJ/s = 8.64×10^{7} *MJ/day =* 8.64×10^{13} *J/day*
In equation 2, 2 atoms He are used.
Mass He used = 10^{-26} *kg and produces* 2.06×10^{-12} *J*
Mass He needed = $10^{-26} \times (8.64 \times 10^{13})/(2.06 \times 10^{-12}) = 0.421$ *kg*
Mass of moon rock = $0.421/10^{-5} = 4.21 \times 10^{4}$ *tonne*

c) Not well done. Many candidates tried to use the chemical principle of activation energy with little success. Others incorrectly used mass as the basis of their discussion rather than charge.

The second reaction has higher positive charged nuclei to fuse so there is more potential energy due to repulsion to be overcome. This means that the colliding particles will need more kinetic energy. This can only be achieved by using higher temperatures.

d) A number of reasonable attempts. Too many candidates did not refer to the listed hint questions and thus found the question more difficult than it needed to be. This is a lesson for future candidates!

Two reasons, each relating to the questions mentioned in the hint, were expected. Question 10 suggests that protons, because they are charged, will be able to be contained by electric or magnetic fields such as in the magnetic bottle. Uncharged neutrons will not be so contained and so will be able to collide with the walls of the reactor and render atoms radioactive (as mentioned in question 21). This would require massive shielding to protect surroundings.

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