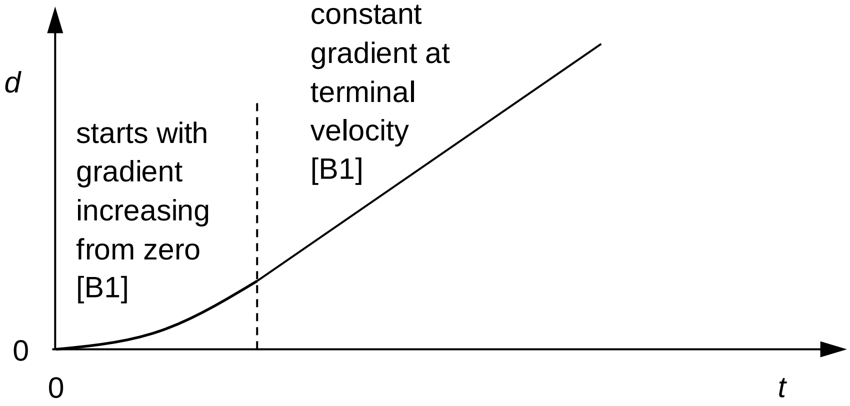
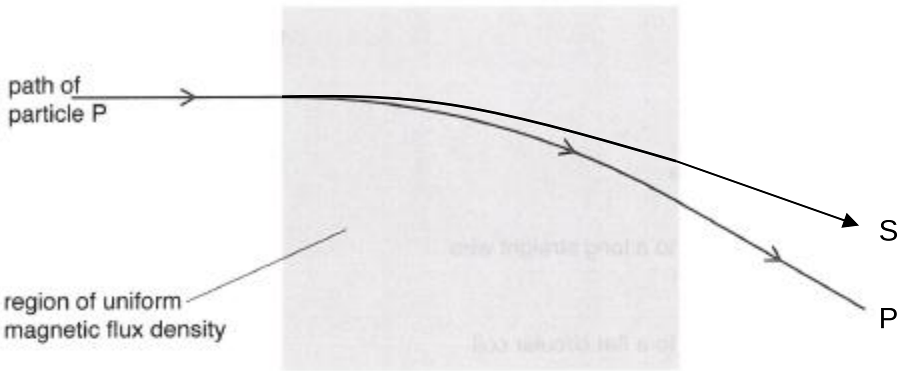
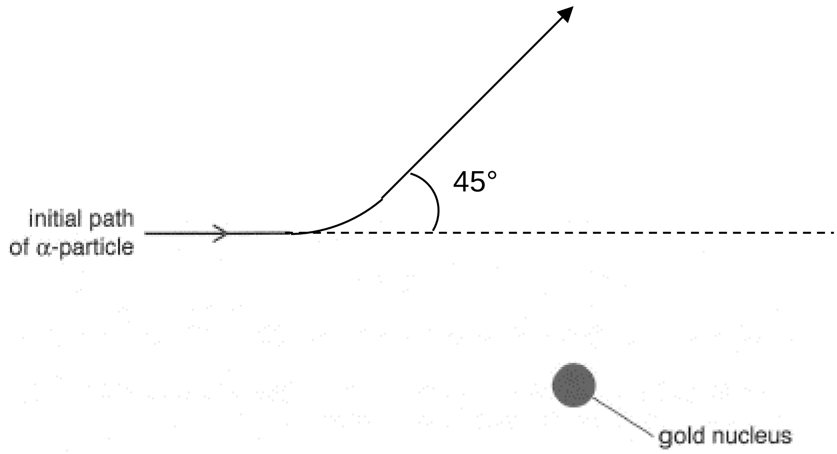
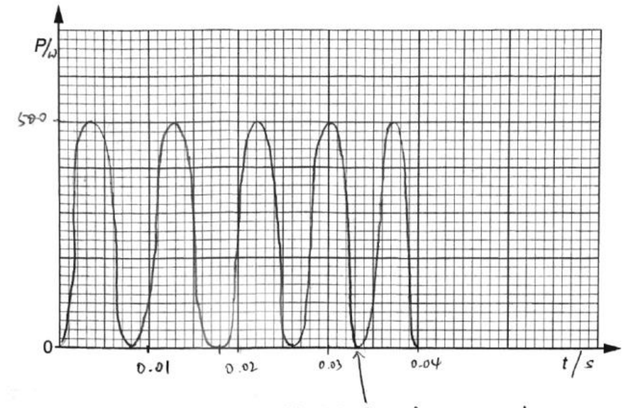
2018 H2 9749 Physics Paper 3

1(a)		
1(b)	Since magnetic force provides for centripetal force, $F_{net} = ma$ $Bqv = m\frac{v^2}{R}$ $R = \frac{mv}{Bq}$ first particle, $R_P = \frac{mv}{Bq}$ second particle, $R_S = \frac{m(2v)}{Bq} = 2R_P$ The circular motion thus has a larger radius. 	

1(c)	 Fig. 1.3	
2(a)(i)	A region of space in which a mass experiences a force of gravity due to the presence of another mass.	[M1] [A1]
2(b)(i)	The distance between the stars is much greater than the diameter of each star (approximately 10^7 to 10^8 times greater) thus the stars are treated as point masses	[B1]
2(b)(ii)	$F = G\frac{Mm}{r^2}$ $= (6.67 \times 10^{-11})\frac{(2.0 \times 10^{30})(2.4 \times 10^{29})}{(4.0 \times 10^{16})^2}$ $= 2.0 \times 10^{16}$ N	[C1] [A1]
2(c)	Using Newton's Second Law of motion, the acceleration due to the force in b(ii) is very small (on the order of 10^{-14} m s^{-2}) in comparison to the motion of the sun.	[M1] [A1]
3(a)(i)	Electric force, F = qE Where E = V / d, V is the potential difference between the plates, d is the distance between the plates Hence F = (3.2×10^{-19}) (900 / 0.036) = 8.0×10^{-15} N Comments: Need to provide some sort of explanation (expected from questions).	

3(a)(ii)	The net force acting on the particle = downwards electric force + weight = $8.0 \times 10^{-15} + (6.6 \times 10^{-27} \times 9.81)$ = 8.0×10^{-15} N By Newton's 2nd Law, $F_{net} = ma$ $8.0 \times 10^{-15} = 6.6 \times 10^{-27} a$ $a = 1.2 \times 10^{12}$ m s^{-2} Comments: In this question, the weight is actually negligible compared to the electric force. However, do not assume that it is always so. Do consider weight at all times.	
3(b)(ii)	Time taken to travel through the plates (cross through horizontally) = $0.075 / (4.1 \times 10^5)$ = 1.829×10^{-7} s Vertical distance travelled (for the above time) = $u_y t + \frac{1}{2} a_y t^2$ = $0 + \frac{1}{2} (1.21 \times 10^{12}) (1.829 \times 10^{-7})^2$ = 0.020 m Since this is more than 0.018 m, the vertical distance from the lower plate, the particle will have collided with the lower plate before exiting the plates. Comments: There are several other different and acceptable solutions.	
4(a)(i)	The magnetic flux density of a magnetic field is defined as the force per unit current per unit length (of conductor) acting on a straight current-carrying conductor placed at right angles to the magnetic field.	[A3]
4(a)(ii)	The magnetic flux through a plane surface is the product of the flux density normal to the surface and the area of the surface. The magnetic flux linkage through a coil of *N* turns is the product of the number of turns *N* of the coil and the magnetic flux linking each turn. Comments: Need to first define magnetic flux when asked about magnetic flux linkage	[M1] [A1]
4(b)	When the switch is closed, the current in the coil produces a magnetic flux within the coil. The magnetic flux within the soft iron core, linking the aluminium ring also increases. By Faraday's Law, this increase in magnetic flux in the ring induces an emf within the ring. Since the ring is a closed loop, there is induced current that flows in the ring. By Lenz's Law, the direction of the induced current is so as to create the magnetic flux in the opposite direction (to oppose the increase in flux). Hence the magnetic field produced by the induced current in the ring is opposite direction to the field produced by the coil. This leads to a repulsive force btween the coil and the ring so that the ring moves vertically.	[M1] [M1] [M1] [A1]

4(c)	Since the ring still experiences a change of magnetic flux when the switch is closed, an emf is induced. However due to the lack of mobile charge carriers, there is no induced current. Hence the ring does not experience any force and will not move.	[M1] [A1]
5(a)(i)	The root mean square value of an alternating current that passes through a resistor is the value of an equivalent steady direct current that would produce the same rate of heating in the resistor as the alternating current. Comments: Please do not just reference to heating, without making it clear that it is the rate of heating that must be considered and that heating takes place in a resistor.	
5(b)(i)	$V_{r.m.s} = \frac{170}{\sqrt{2}} = 120V$	
5(b)(ii)	$\omega = 2\pi f = 377$ $f = \frac{377}{2\pi} = 60Hz$	
5(b)(iii)	$P_{mean} = \frac{V^2_{r.m.s}}{R} = \frac{120^2}{58} = 250W$	
5(c)	 Fig. 5.2 time for 2 periods = 0.033 s Comments: Please ensure that there are 4 cycles (or 2 periods) and units areclearly stated. The peak power should be 500 not '249' or '250'.	

6(a)	A photon is a discrete bundle (or <u>quantum</u>) of <u>electromagnetic</u> energy. Comments: Recognise that photon is a quantum of energy and that this energy is an electromagnetic radiation.	[B2]
6(b)(i)	$E_1 = \frac{hc}{\lambda}$ $= \frac{(6.63 \times 10^{-34})(3.00 \times 10^{8})}{(680 \times 10^{-9})}$ $= 2.925 \times 10^{-19} = 2.9 \times 10^{-19}$ J	 [C1] [A1]

<table>
<tr>
<td>6(b)(ii)</td>
<td>$A=\pi\left(\frac{1.2\times10^{-3}}{2}\right)^2=1.131\times10^{-6}\ \text{m}^2$ [M1]

$I=\frac{P}{A}=\frac{N}{t}\frac{E_1}{A}$

$\frac{N}{t}=\frac{(3.1\times10^{3})(1.131\times10^{-6})}{(2.925\times10^{-19})}$ [M1]

$=1.2\times10^{16}$ (shown) [A0]

Comments: Show all substitutions clearly.</td>
<td></td>
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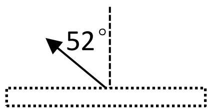
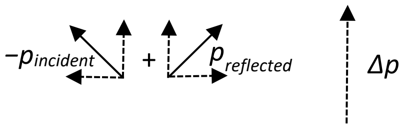
<tr>
<td>6(c)</td>
<td>Momentum of each photon, $p_1=\frac{h}{\lambda}=\frac{6.63\times10^{-34}}{680\times10^{-9}}=9.75\times10^{-28}\ \text{kg m s}^{-1}$

<u>For the absorbed light</u>
By Newton's 2nd Law
Net force on absorbed light $F_A=(45\%)\frac{N}{t}(0-p_1)$
$=0.45(1.2\times10^{16})(-9.75\times10^{28})$
$=-5.265\times10^{-12}$ N
or 5.265×10^{-12} N at 52° anticlockwise from the vertical


<u>For the reflected light</u>
By Newton's 2nd Law
Net force on reflected light $F_R=(55\%)\frac{N}{t}(p_{reflected}-p_{incident})$
$=0.55(1.2\times10^{16})(9.75\times10^{-28}\cos52^\circ-(-9.75\times10^{-28}\cos52^\circ))$
$=7.9236\times10^{-12}$ N (vertically upwards)


<u>Total force normal to surface</u>
Total force on light normal to surface $=5.265\times10^{-12}\cos52^\circ+7.9236\times10^{-12}$
$=1.12\times10^{-11}$ N
By Newton's 3rd Law
Magnitude of force F normal to surface exerted by light
= Magnitude of force normal to surface exerted on light
= 1.12×10^{-11} N

Comments: Student must consider the force on absorbed and reflected light separately.</td>
<td>[M1]

[M1]

[M1]

[M1]

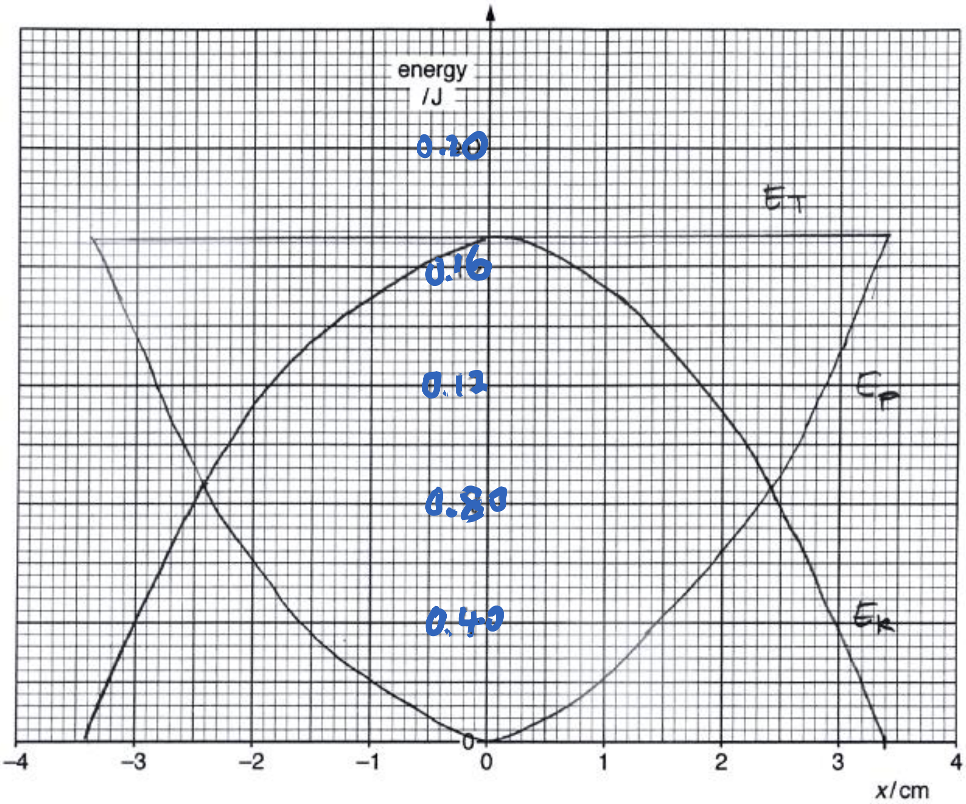
[M1]

[A1]</td>
</tr>
</table>

7(a)	(i) The rate of decay for a given specimen fluctuates and it is not possible to predict exactly how many decays will occur for a given time interval. (ii) The rate of decay for a given specimen is not affected by external conditions, such as pressure or temperature. Comments: Must answer to the question and state the *experimental evidence* as required. Answers related to the probability of decay of a nucleus is not accepted as experimental evidence.	
7(b)	From the graph, $A_o = 5.8 \times 10^5\ s^{-1}$ $A = 1.0 \times 10^5\ s^{-1}$ after 37.5 days $A = 2.3 \times 10^5\ s^{-1}$ after 20 days $1.0 \times 10^5 = 5.8 \times 10^5\ e^{-37.5\lambda}$ $\lambda = 0.04688\ day^{-1} = 5.43 \times 10^{-7}\ s^{-1}$ $2.3 \times 10^5 = 5.8 \times 10^5\ e^{-20\lambda}$ $\lambda = 0.04625\ day^{-1} = 5.35 \times 10^{-7}\ s^{-1}$ Ave $\lambda = 5.39 \times 10^{-7}\ s^{-1}$ Comments: The graph given covers 40 days, which is several half-lives. Students are expected to use good experimental practice and take more than just one measurement of the half-life.	
7(c)	$A_o = 5.8 \times 10^5\ s^{-1} = 5.3 \times 10^{-7} N_o$ $N_o = 1.09 \times 10^{12}$ Mass = $(1.09 \times 10^{12} / 6.02 \times 10^{23}) \times 32$ g $= 5.8 \times 10^{-11}$ g	
8(a)(i)	The internal energy of a system is the sum of a random distribution of kinetic and potential energies associated with the molecules of a system. [A2]	
8(a)(ii)	$+q$: heat supplied to the system [A1] $+w$: work done on the system [A1]	
8(b)(i)	An ideal gas is one that obeys the equation of state $pV = nRT$ at all pressures p, volumes V and temperatures T. [A2]	
8(b)ii)1.	$pV = NkT$ [C1] $(5.4\times10^5)(1.2\times10^4\times10^{-6}) = N(1.38\times10^{-23})(273+57)$ [C1] $N = 1.4229\times10^{24}$ $= 1.4\times10^{24}$ [A1]	

8(b)ii)2.	$E=\frac{3}{2}kT$ $=\frac{3}{2}\left(1.38\times10^{-23}\right)\left(273+57\right)$ [C1] $=6.8\times10^{-21}$ J [A1]	
8(b)ii)3.	Since the gas is ideal, there are no intermolecular forces. Hence, Potential energy of the molecules is zero. [M1] total internal energy = total kinetic energy of the gas particles $=$ number of molecules $\times$ mean. KE of one molecule $=\left(1.4229\times10^{24}\right)\times\left(6.831\times10^{-21}\right)$ $=9720$ J [A1]	
8(c)(i)	$\Delta U=\frac{3}{2}Nk\Delta T$ [C1] $=\frac{3}{2}\left(1.4229\times10^{24}\right)\left(1.38\times10^{-23}\right)\left(155-57\right)$ [C1] $=2890$ J [A1]	
8(c)(ii)1.	By First Law of Thermodynamics, since increase in internal energy of the gas is equal to the heat supplied to the gas, then work done on the gas must be zero. [M1] Since work done on gas is directly proportional to the change in volume of the gas, then volume must also remain constant. [A1]	
8(c)(ii)2.	Change in temperature = 98 K Number of mole of gas $=\frac{1.4229\times10^{24}}{6.02\times10^{23}}=2.364$ $C=\frac{2886}{\left(2.364\right)(98)}$ [C1] $=12.5$ J mol^{-1} K^{-1} [A1]	

9(a)(i)	**Simple harmonic motion** is the periodic motion of a particle whose acceleration is proportional to its displacement *x* from a fixed point, and is directed towards the point.	
9(a)(ii)1	From the graph, the mass underwent positive and negative displacements indicating that the mass is oscillating. **Note**: Do not quote definition once again. Need to refer to graph!	B1
9(a)(ii)2	From the graph, the line is curving towards larger positive displacement. Hence, the acceleration is not proportional to the displacement. **Note:** Must make reference to the line (curved part), not just proportionality.	
9(b)(i)1.	At the highest position of the plate. **Note**: Do not use 'maximum amplitude' (as this is not answering the question about position)	
9(b)(ii)2.	$a=-\omega^2 x$ $9.81=\left(2\pi\times 13\right)^2 x$ [amplitude only] $x=1.47\times 10^{-3}$ m $=1.47$ mm	
9(b)(ii)	The acceleration due to free fall (9.81 m s^{-2}) is constant and independent of mass. Hence, the sand or pebbles will lose contact with the plate as long as the pate is accelerating downwards at 9.81 m s^{-2}. As such, the minimum amplitude of oscillations would not be different.	
9(c)(i)1.	Total energy = Maximum KE $=\frac{1}{2}m(v_{\text{max}})^2$ $=\frac{1}{2}m\omega^2 {x_o}^2$ $=\frac{1}{2}(1.2)(2\pi\times 2.5)^2(0.034)^2$ $=0.17$ J **Note:** For SHM, there is exchange of KE and GPE. Hence, there is no need to consider GPE at the maximum KE.	
9(c)(i)2.	Ep = Ek $\frac{1}{2}\text{m}\omega^2 d^2=\frac{1}{2}m\omega^2\left({x_o}^2-d^2\right)$ $d^2=\frac{1}{2}{x_o}^2(1.2)(2\pi\times 2.5)^2(0.034)^2$ $d=\frac{3.4}{\sqrt{2}}=2.4$ cm	

9(c)(i)3.	 Fig. 9.4 [6] [B1] Correct x and y axis intercept for Ek [B1] Correct y axis intercept for Ep, correct coordinates of (-3.4, 0.17), (+3.4, 0.17) [B1] Total energy line is from -3.4 cm to +3.4 cm only [B1] Smooth curve for Ek [B1] Smooth curve for Ep [B1] Correct intersection of Ek and Ep at -2.4 cm and +2.4 cm	