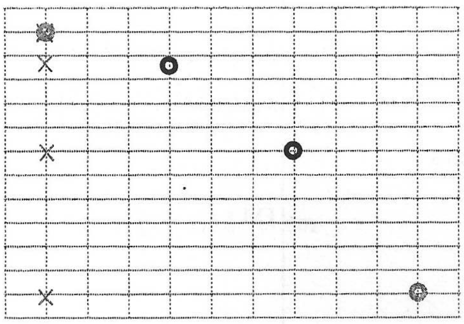
Paper 1 Section A

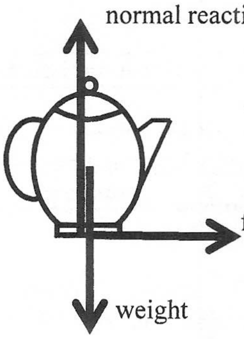
Question No.	Key	Question No.	Key
1.	D (86)	26.	A (46)
2.	C (88)	27.	B (73)
3.	A (68)	28.	C (46)
4.	D (72)	29.	A (68)
5.	A (70)	30.	D (54)
6.	A (67)	31.	A (57)
7.	C (93)	32.	C (64)
8.	B (75)	33.	B (69)
9.	B (68)		
10.	A (40)		
11.	B (57)		
12.	C (89)		
13.	C (59)		
14.	A (54)		
15.	D (61)		
16.	C (77)		
17.	B (42)		
18.	D (73)		
19.	D (51)		
20.	B (63)		
21.	C (66)		
22.	B (63)		
23.	D (55)		
24.	B (62)		
25.	D (70)		

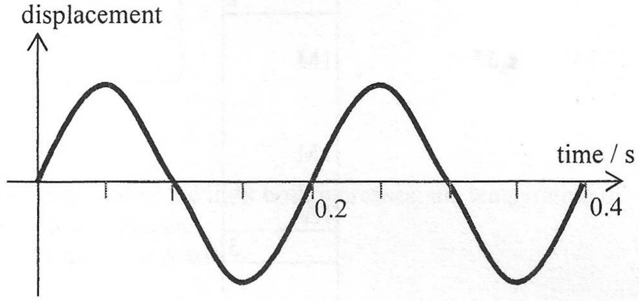
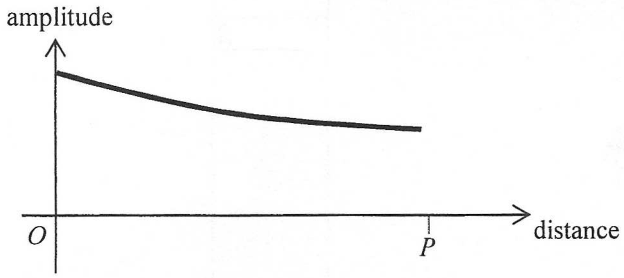
Note: Figures in brackets indicate the percentages of candidates choosing the correct answers.

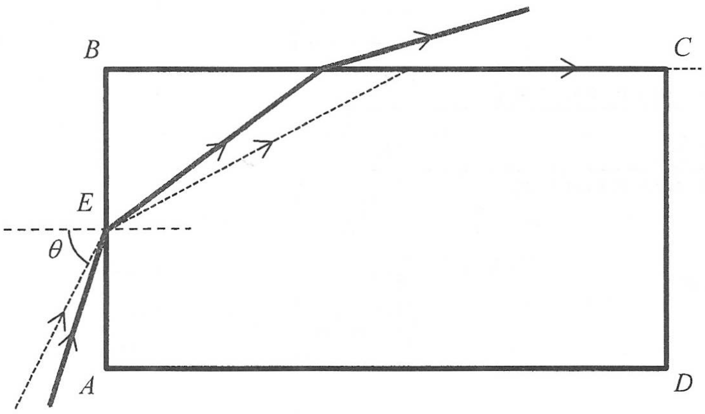
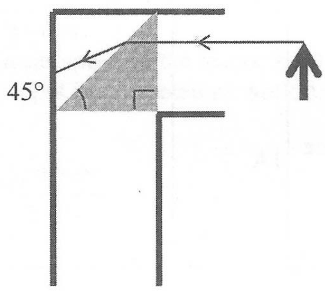
Paper 1 Section B

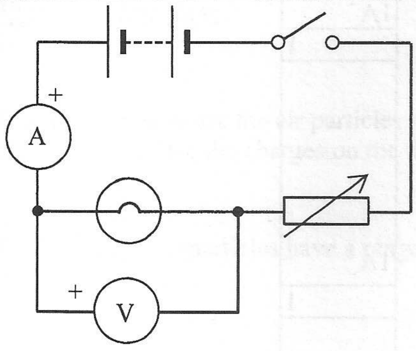
Solution	Marks	Remarks
1. (a) A larger bulb improves the sensitivity of the thermometer.	1A	
Or A larger bulb minimizes the effect on the temperature reading due to the other parts of the thermometer stem that are exposed to different temperatures.	1A	
	1	
(b) (i) $E = mc\Delta T$ $= 0.015 \times (2.9 \times 10^3) \times (20 - 15)$	1M	
$= 217.5$ J	1A	
	2	
(ii) Time taken to reach air temperature $= \frac{217.5}{0.5}$	1M	
$= 435$ s	1A	
	2	
(iii) The thermometer would be in direct contact with the cooler air and would cool down quickly.	1A	
The temperature reading would be less than the actual soil temperature.	1A	
	2	
2. Measure the mass of a bullet m and the mass of the trolley with plasticine M.	1A	
Fire the bullet towards the plasticine.	1A	
Read the speed of the trolley v immediately after the bullet hit the plasticine.	1A	
The speed of the bullet u is given by $u = \frac{M+m}{m}v$.	1A	
Precaution: (Any **ONE**) - The bullet should be fired close to the plasticine.	1A	
- The bullet should be fired along the direction of travel of the trolley.	1A	
- The track must be horizontal / friction compensated.	1A	
	5	

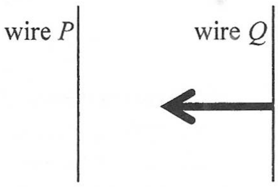
Solution	Marks	Remarks
3. (a) $\dfrac{(c_{rms})_f}{c_{rms}} = \sqrt{\dfrac{T_f}{T}}$	1M	
$\dfrac{c_{\text{r.m.s.}} \text{ at } 350\text{K}}{c_{\text{r.m.s.}} \text{ at } 300\text{K}} = \sqrt{\dfrac{350}{300}}$		
$= 1.08$	1A	
	2	
(b) The speed of the gas molecules increases. They collide more frequently and violently with the wall of the container. Thus, the pressure increases.	1A+1A	
	2	
4. (a) (i) By $s = ut + \frac{1}{2}gt^2$		
$0.11 = \frac{1}{2}g(0.05 \times 3)^2$	1M	
$g = 9.78 \text{ m s}^{-2}$	1A	
	2	
(ii) (1) 	1A 1A	Correct horizontal positions Correct vertical positions
	2	
(2) $v_x = 1 \text{ m s}^{-1}$		
$v_y = u_y + gt$ $= 0 + 9.78 \times (0.05 \times 3)$	1M	
$= 1.47 \text{ m s}^{-1}$		
$v = \sqrt{v_x^2 + v_y^2}$		
$= \sqrt{1^2 + 1.47^2}$	1M	
$= 1.78 \text{ m s}^{-1}$	1A	
	3	
(b) The air resistance acting on the ball increases as its speed increases.	1A	
When the air resistance equals to the weight of the ball,	1A	
net force acting on the ball becomes zero, by Newton's first law of motion, the ball travels with constant speed.	1A	
Or net force acting on the ball becomes zero, by Newton's second law of motion, the ball will not accelerate further and travels with constant speed.	1A	
	3	

Solution	Marks	Remarks
5. (a) 	1A+1A	
	2	
(b) $\omega = \pi\ s^{-1}$	1A	
$F = mr\omega^2$		
$= (1)(0.3)(\pi)^2$	1M	
$= 2.96$ N (towards the centre of the turntable)	1A	
Alternative method:		
$v = 0.3\pi$ m s^{-1}	1A	
$F = m\frac{v^2}{r}$	1M	
$= 2.96$ N	1A	
	3	
(c) The initial linear speed of the teapot $= r\omega = 0.3\pi$ m s^{-1}		
Deceleration of the teapot $a = \frac{f}{m} = \frac{10}{1} = 10$ m s^{-2}	1M	
Distance travelled s is given by		
$v^2 - u^2 = 2as$		
$s = \frac{u^2}{2a} = \frac{(0.3\pi)^2}{2(10)}$	1M	
$= 0.044$ m (or 4.4 cm)	1A	
Alternative method:		
The initial linear speed of the teapot $= r\omega = 0.3\pi$ m s^{-1}	1M	
K.E. of the teapot is dissipated as work done against friction		
$\frac{1}{2}mu^2 = fd$		
$d = \frac{mu^2}{2f} = \frac{(1)(0.3\pi)^2}{2(10)}$	1M	
$= 0.044$ m	1A	
	3	

Solution	Marks	Remarks
6. (a) (i) $v = f\lambda$		
$= 5 \times 4$	1M	
$= 20$ cm s^{-1}	1A	
	2	
(ii) Y is moving upwards at $t = 0$.	1A	
	1	
(iii) 	1A 1M	
	2	
(b) (i) The water waves from A and B are in anti-phase at Q.	1M	
Or		
The path difference at $Q = (n + 1/2)\lambda$.	1M	
Destructive interference occurs to form a minimum.	1A	
	2	
(ii) Path difference at $Q = 1.5\lambda = 3$ cm	1M	
$\lambda = 2$ cm	1A	
	2	
(iii) 	1A	
	1	

Solution	Marks	Remarks
7. (a) (i) At the critical angle c,		
$\dfrac{\sin 90^\circ}{\sin c} = n$		
$\dfrac{1}{\sin c} = 1.36$	1M	
$c = 47.3^\circ$	1A	
	2	
(ii) Angle of refraction at $E = 90^\circ - 47.33^\circ = 42.67^\circ$	1M	
By Snell's law		
$\dfrac{\sin \theta}{\sin 42.67^\circ} = 1.36$	1M	
$\theta = 67.2^\circ$	1A	
	3	
(iii) 	2A	
	2	
(b) (i) 	1A	
The angle of incidence of the light ray from the object is (45°, which is) less than the critical angle of the plastic prism.	1A	
Total internal reflection will not occur and the image may not be clear enough for observation.	1A	
	3	
(ii) Glass prism (with critical angle less than 45°)	1A	
Or Plane mirror	1A	
	1	

	Solution	Marks	Remarks
8.	(a) 	1A 1A 1A 3	Correct symbols of light bulb, variable resistor and voltmeter Correct positions Correct positive terminal connection for the voltmeter
	(b) As the voltage across the light bulb increases, the temperature of the light bulb increases, thus its resistance increases.	1A 1A 2	
	(c) $R=\frac{V}{I}$ is the definition of resistance. It is applicable to all conductors.	1A 1	
	(d) At $V = 0.1$ V $R=\frac{V}{I}=\frac{0.1}{76\times10^{-3}}=1.32\ \Omega$ At $V = 2.5$ V $R=\frac{V}{I}=\frac{2.5}{250\times10^{-3}}$ $= 10\ \Omega$	1A 1A 1A 3	for reading correct values (ignore the order of magnitude) from the graph
	(e) $R=\rho\frac{l}{A}$ $l=\frac{RA}{\rho}$ $=\frac{1.32\times(1.66\times10^{-9})}{5.6\times10^{-8}}$ $= 0.039$ m	1M+1M 1A 3	

Solution	Marks	Remarks
9. (a) (i) The magnetic field at Q due to P points out of the paper.	1A	
	1	
(ii) 	1A	
	1	
(iii) The magnetic field at Q due to P is		
$B_Q = \dfrac{\mu_0 I_P}{2\pi r}$	1M	
For a certain length segment l of wire, the magnetic force is		
$F = B_Q I_Q l \sin\theta$		
$= \dfrac{\mu_0 I_P}{2\pi r} I_Q l$	1M	
The magnetic force per unit length is		
$F_l = \dfrac{F}{l} = \dfrac{\mu_0 I_P I_Q}{2\pi r}$	1M	
	3	
(iv) The two forces form an action and reaction pair,	1A	
thus they are equal in magnitude.	1A	
	2	
(b) (i) As current passes in the same direction between neighbouring wire segments,	1A	
the wire segments attract each other, and the solenoid is compressed.	1A	
	2	
(ii) Current keeps on flowing in the same direction between neighbouring wire segments at each instant, thus the solenoid will be compressed due to magnetic force.	1A	
	1	

Solution		Marks	Remarks
10. (a)	$^{210}_{84}Po \rightarrow ^{206}_{82}Pb + ^{4}_{2}He$	2A	
		2	
(b)	The α-particles ionize the air particles. The ions neutralize the charges on the dust/photo or film surface.	1A 1A	
		2	
(c)	This is because α-particles have a range of only a few centimeters in air.	1A	
		1	
(d)	Activity after 1 year $= \left(\frac{1}{2}\right)^{\frac{365}{138}}$ $= 0.160$ unit	1M 1A	
	Alternative method: $A = A_0 e^{-\frac{ln2}{t_{1/2}}t}$ $= 1 \times e^{-\frac{ln2}{138}(365)}$ $= 0.160$ unit	 1M 1A	
		2	

Paper 2

Section A : Astronomy and Space Science

1. C (55%)	2. B (52%)	3. C (55%)	4. B (51%)
5. D (62%)	6. D (61%)	7. A (53%)	8. A (65%)

Solution	Marks	Remarks
1. (a) (i) $\frac{GMm}{r^2} = \frac{mv^2}{r}$ $v^2 = \frac{GM}{r}$	1M	
	1	
(ii) $T = \frac{2\pi r}{v}$	1M	
$T^2 = \frac{4\pi^2 r^2}{v^2}$ $= \frac{4\pi^2 r^2}{\left(\frac{GM}{r}\right)}$ from (i)	1M	
$= \frac{4\pi^2}{GM} r^3$		
	2	
(b) (i) By $\frac{\Delta\lambda}{\lambda_0} \approx \frac{v}{c}$ $\Delta\lambda \approx \frac{v}{c}\lambda_0 = \frac{1.23\times10^5}{3\times10^8} \times 21.106$ $= 8.65346 \times 10^{-3}$ cm	1M	
$\lambda = \lambda_0 - \Delta\lambda$ $= 21.106 - 8.65346 \times 10^{-3}$ $= 21.097$ cm	1A	
	2	
(ii) $T = \frac{2\pi r}{v}$ $= \frac{2\times3.14\times(3.98\times10^{20})}{1.23\times10^5}$ $= 2.03 \times 10^{16}$ s (or 6.42×10^8 yr)	1A	
	1	

Solution	Marks	Remarks
1. (b) (iii) For the hydrogen gas orbiting the M33 Galaxy at X, $T^2 = \frac{4\pi^2}{GM} r^3$ ……(1) where T is the answer in (b)(ii), M is the mass of the M33 Galaxy and r is the distance between position X and the centre of the galaxy. Consider the Earth orbiting around the Sun, $T_S^2 = \frac{4\pi^2}{GM_S} r_S^3$ ……(2) where T_S = 1 year, r_S = 1 AU and M_S is the solar mass.	1M	
$\frac{(1)}{(2)}$ and we have $\frac{T^2}{T_S^2} = \frac{M_S r^3}{M r_S^3}$ $M = \frac{T_S^2 r^3}{T^2 r_S^3} M_S$	1M	
$= \left(\frac{3.16\times10^7}{2.03\times10^{16}}\right)^2 \left(\frac{3.98\times10^{20}}{1.50\times10^{11}}\right)^3 M_S$ $= 4.526 \times 10^{10}\ M_S \approx 4.53 \times 10^{10}\ M_S$	1A	
Alternative method: Use $T^2 = \frac{4\pi^2}{GM} r^3$ to find the mass of M33 $M = \frac{4\pi^2 (3.98\times10^{20})^3}{G(2.03\times10^{16})^2} = 9.055 \times 10^{40}$ kg	1M	
Use $T_S^2 = \frac{4\pi^2}{GM_S} r_S^3$ to find solar mass $M_S = \frac{4\pi^2 (1.5\times10^{11})^3}{G(3.16\times10^7)^2} = 2.0 \times 10^{30}$ kg	1M	
Then $M = 4.526 \times 10^{10}\ M_S$	1A	
	3	
(iv) Dark matter / a (super) massive black hole / non-luminous object exists in the galaxy.	1A	
	1	

Section B : Atomic World

1. B (70%)	2. A (30%)	3. C (57%)	4. C (60%)
5. B (52%)	6. A (64%)	7. A (70%)	8. D (70%)

Solution	Marks	Remarks
2. (a) When an atom transits from a higher energy level to a lower one, a photon with energy equals to the energy difference between the levels is emitted.	1A	
Since energy levels are quantized, the energy (and thus wavelength) of the photons emitted can take some discrete values only.	1A	
	2	
(b) (i) Line X belongs to the ultra-violet region.	1A	
	1	
(ii) energy = $\frac{hc}{\lambda e}$		
$= \frac{(6.63\times10^{-34})(3\times10^{8})}{(366\times10^{-9})(1.60\times10^{-19})}$	1M	
= 3.40 eV	1A	
	2	
(iii) The radiation would be absorbed,	1A	
and the hydrogen atoms ionized.	1A	
	2	
(c) (i) The transition from $n = 3$ to $n = 2$. (i.e. from 2nd to 1st excited state)	1A	
	1	
(ii) From line X, we have $\frac{1}{366} = R(\frac{1}{2^2} - 0)$	1M	
$R \approx 0.0109$ (nm^{-1}) (or 1.09×10^{7} m^{-1}) For line Y, $\frac{1}{\lambda} = R(\frac{1}{2^2} - \frac{1}{3^2})$		
$\lambda = 658.8$ nm	1A	
Alternative method: $R = \frac{13.6\text{ eV}}{hc} = \frac{13.6\times(1.6\times10^{-19})}{(6.63\times10^{-34})(3\times10^{8})}$		
[Or: $E = E_2 - E_3$; $h\frac{c}{\lambda} = 13.6\left(\frac{1}{2^2} - \frac{1}{3^2}\right)$ eV]	1M	
$= 1.094\times10^{7}$ (m^{-1}); $\frac{1}{\lambda} = R(\frac{1}{2^2} - \frac{1}{3^2})$ [Or: $= 13.6\left(\frac{1}{2^2} - \frac{1}{3^2}\right)\times1.6\times10^{-19}$]		
$\lambda = 6.58\times10^{-7}$ m [Or: $\lambda = 6.58\times10^{-7}$ m]	1A	
	2	

Section C : Energy and Use of Energy

1. B (63%)	2. C (89%)	3. B (75%)	4. D (73%)
5. C (57%)	6. D (38%)	7. *	8. A (52%)

Solution	Marks	Remarks
3. (a) (i) The refrigerant flows from indoor to outdoor through the compressor.	1A	
	1	
(ii) The refrigerant condenses / changes from gas to liquid. It releases the heat/internal energy to the environment.	1A 1A	
	2	
(b) (i) Total surface area = $(4 \times 2) \times 4 + (2 \times 2) \times 2 = 40\ \text{m}^2$ Cooling capacity = rate of heat gain $= \kappa \dfrac{A(T_H - T_C)}{d} = 0.03 \dfrac{40(50)}{0.08}$ $= 750\ \text{W}$	1M 1M 1A	
	3	
(ii) The compartment absorbs heat by radiation, the exterior surface temperature of the refrigerated compartment is higher than 35 °C. Thus, the interior will be higher than −15 °C.	1A 1A	The compartment also absorbs heat from the engine / exhaust system.
	2	
(c) Light emitting diode (LED) has a long life time and very high efficacy.	1A 1A	
	2	

*This item was deleted.

Section D : Medical Physics

1. A (69%)	2. C (40%)	3. B (72%)	4. D (58%)
5. B (57%)	6. A (72%)	7. C (65%)	8. D (53%)

Solution	Marks	Remarks
4. (a) X-ray is produced when fast electrons hit a heavy metal target.	1A	
	1	
(b) CT scan is better at mapping soft tissues / differentiating between overlying structures in the body / making 3D images	1A	
	1	
(c) (i) The effective dose of CT scan is much higher because multiple X-ray images are taken for a CT scan.	1A	
	1	
(ii) Equivalent background radiation dose $= 1.85 \times \frac{1.5}{0.02}$ $= 138.75$ days	1A	
	1	
(d) (i) The lung cavity is filled with air / There is a large difference in density between the lung cavity and bone	1A	
	1	
(ii) $I = I_0 e^{-(\mu_1 x_1 + \mu_2 x_2 + \mu_3 x_3)}$		
$\frac{I}{I_0} = e^{-(0.1 \times 19.8 + 0.18 \times 8.8 + 0.48 \times 4.4)}$	1M+1M	
$= e^{-5.676} = 3.43 \times 10^{-3}$	1A	
	3	
(e) I do not agree because a CT scan may cause ionization (changes) in cells / damage DNA of the foetus.	1A	
An ultrasound scan can be used for checking a foetus.	1A	
	2	