Paper 1 Section A

Question No.	Key	Question No.	Key
1.	A (62)	26.	C (35)
2.	A (78)	27.	B (51)
3.	C (53)	28.	A (62)
4.	B (43)	29.	C (70)
5.	D (35)	30.	D (69)
6.	D (62)	31.	B (84)
7.	C (58)	32.	D (76)
8.	A (44)	33.	D (48)
9.	A (53)		
10.	C (75)		
11.	B (85)		
12.	C (68)		
13.	B (63)		
14.	D (47)		
15.	B (61)		
16.	B (63)		
17.	D (61)		
18.	C (56)		
19.	A (56)		
20.	C (33)		
21.	D (76)		
22.	A (28)		
23.	B (47)		
24.	A (45)		
25.	C (63)		

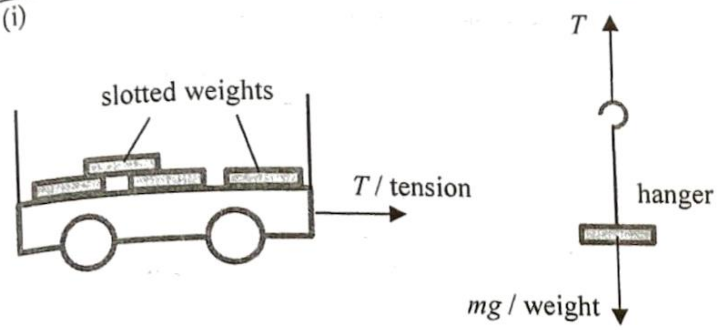
Note: Figures in brackets indicate the percentages of candidates choosing the correct answers.

Paper 1 Section B

Solution	Marks	Remarks
1. (a) $Pt = ml$		
$l = \dfrac{150 \times (5\times60)}{0.016}$	1M	
$= 2812500 \text{ J kg}^{-1} \approx 2810 \text{ kJ kg}^{-1}$	1A	
	2	
(b) $C\,(100 - 22) = m_w c_w\,(22 - 20)$		
$C = \dfrac{0.100 \times 4200(22-20)}{(100-22)}$	1M	
$= 10.76923 \text{ J °C}^{-1} \approx 10.8 \text{ J °C}^{-1}$	1A	
	2	
(c) Since energy transferred by the boiling water is taken to be energy from the metal sphere / extra energy is transferred (by the boiling water) to the cup of water / the final temperature is higher.	1A	
The true value of C is smaller (than the calculated value).	1A	
	2	
(d) Not justified (with correct explanation).	1A	
Copper – (good) conductor while polystyrene – (good) insulator or poor conductor, more energy will be lost to the surroundings by conduction via a copper cup / most part of the polystyrene cup is still at room temperature, negligible energy is absorbed.	1A	
	2	

Solution	Marks	Remarks
2. (a) $v = \frac{30 \times 2}{0.04}$	1M	
$= 1500 \text{ m s}^{-1}$	1A	
	2	
(b) (i) $\frac{p_1}{T_1} = \frac{p_2}{T_2}$ $\frac{18.5}{273+27} = \frac{p_2}{273+20}$	1M	
$p_2 = 18.068333 \text{ atm} \approx 18.1 \text{ atm}$		
	1	kinetic theory
(ii) As the temperature decreases, the speed / kinetic energy of the gas molecules decreases.	1A	
They collide less frequently and/or violently with the wall of the container / cylinder. Thus, the pressure decreases.	1A	
	2	
(c) (i) $n_0 = n_1 + n_2$ $p_0 V_0 = p_1 V_1 + p_2 V_2$ fixed volume (container)	1M	Assume no leakage
$18.1 \times 0.012 = p_1 \times 0.012 + 4.0 \times 0.015$ $p_1 = 13.1 \text{ atm}$ (i.e. $\Delta p = 5.0 \text{ atm}$)	1M	
	2	
(ii) The pressure decreases by 5.0 atm for inflating one balloon, assume k balloons can be inflated completely: $18.1 - 5.0k \geq 4.0$ or $k \leq \frac{18.1-4.0}{5.0} = 2.82$	1M	Accept: 18.1 atm → 13.1 atm → 8.1 atm $\therefore k = 2$
$\therefore k = 2$ ↳ seabed atm, 出唔到氣	1A	
Or Let V = volume of compressed gas under 4.0 atm $18.1 \times 0.012 = 4.0 \times V$ $V = 0.0543 \text{ m}^3$ $0.0543 - 0.015 \times k \geq 0.012$	1M	
$k \leq 2.82$ $\therefore k = 2$	1A	
	2	

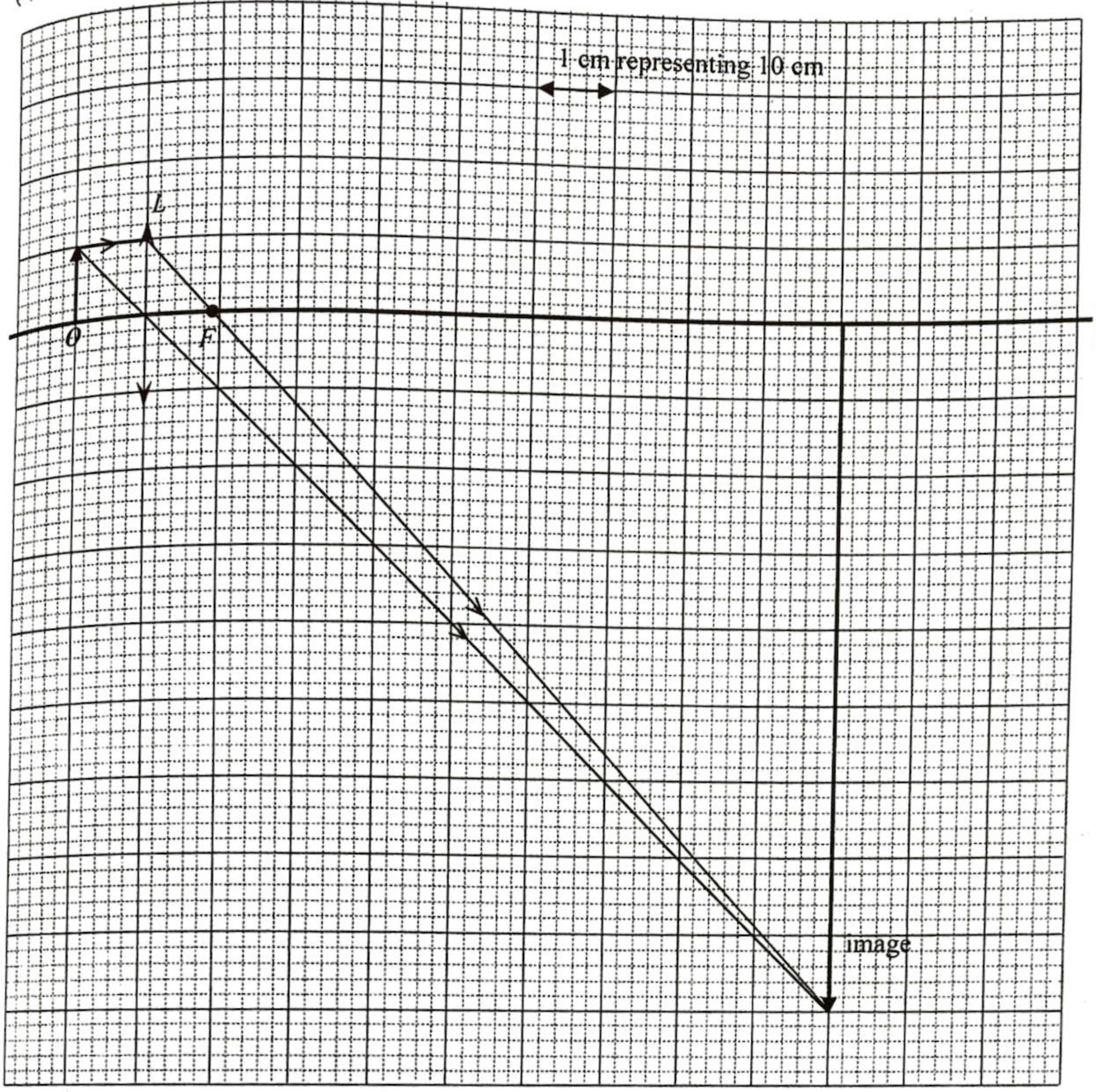
Solution				Marks	Remarks
3.	(a)	(i)	Work done = K.E. gained = ½ (0.22) (13.4)^2 = 19.7516 J ≈ 19.8 J	1M 1A 2	
		(ii)	By conservation of mechanical energy, $\frac{1}{2}mv^2 - \frac{1}{2}mu^2 = mgh$ $v^2 - 13.4^2 = 2(9.81)(1.0)$ $v = 14.113114$ m s^{-1} ≈ 14.1 m s^{-1}	1M 1A	For $g = 10$ m s^{-2}, $v = 14.13$ m s^{-1}
			Or $v_y^2 = u_y^2 + 2as$ $v_y^2 = (13.4 \sin 55°)^2 + 2(-9.81)(-1.0)$ $v_y = 11.836662$ m s^{-1} ≈ 11.8 m s^{-1} speed $v = \sqrt{v_x^2 + v_y^2}$ $= \sqrt{11.8^2 + (13.4 \cos 55°)^2}$ = 14.113079 m s^{-1} ≈ 14.1 m s^{-1}	1M 1A 2	Accept 14.1 m s^{-1} to 14.2 m s^{-1}
	(b)	(i)	descending (a pointing downward) $-g$	1A 1	
		(ii)	$\frac{18}{2} = 13.4 \cos 55° \times t$ (constant horizontal speed) $t = 1.170971$ s ≈ 1.17 s	1M 1A 2	
	(c)		Justified (with correct explanation) Horizontal component of the (initial) velocity is (greatly) increased (for a similar speed but at a much smaller angle (35° << 55°)) Or Vertical component of the (initial) velocity is (greatly) reduced / vertical height reached is smaller. Time of flight (to the highest point as well as) for the whole journey would be shortened.	1A 1A 2	
	(d)		(Wood is soft compared to concrete, thus) it lengthens the time of impact when the feet land on the ground. This reduces the impact force. [as net force $F = \frac{mv - mu}{t} = \frac{0 - mu}{t}$]	1A 1A 2	

Solution	Marks	Remarks
4. (a) (i) 	1A 1A	
	2	
(ii) Smaller than (the weight of hanger / mg), i.e. $T < mg$, therefore by Newton's second law, a net force F is provided for the downward acceleration of the hanging mass Or therefore by Newton's second law, a downward net force F is provided for the acceleration of the hanging mass (both F and a are downward).	1A 1A	
	2	
(iii) Applying Newton's second law to the whole system, $mg = (M + 0.1)\ a$	1A	
	1	
(b) slope of the graph $= \frac{2.5}{0.1} = 25$ (m s^{-2} kg^{-1}) or 0.025 (m s^{-2} g^{-1}) $mg = (M + 0.1)\ a$ $a = \frac{g}{M+0.1} \times m$ $\therefore$ slope of the graph $= 25 = \frac{9.81}{M+0.1}$ $M = 0.2924$ kg ≈ 292 g ≈ 0.3 kg	1A 1M 1A	For $g = 10$ m s^{-2}, $M = 0.3$ kg
	3	

Solution	Marks	Remarks
5. (a) (i) $F = \frac{\Delta p}{\Delta t} = \frac{2.60\times10^3 \times v}{1} = 5.20 \times 10^6$	1M	force on gas = thrust on rocket in magnitude
$v = 2000 \text{ m s}^{-1}$	1A	
	2	
(ii) $F - mg = ma$		
$a = \frac{F}{m} - g = \frac{5.2\times10^6}{3.6\times10^5} - 8.56$	1M	
$= 5.884444 \text{ m s}^{-2} \approx 5.88 \text{ m s}^{-2}$	1A	Accept 5.88 m s^{-2} to 5.90 m s^{-2}
	2	
F=ma		
(iii) The acceleration would increase.	1A	
Although the thrust remains the same, the mass of the rocket and/or g decreases.	1A	
	2	
(b) (i) 24 hours / 1 day / 86400 s	1A	
	1	
(ii) $m\omega^2 r = \frac{GMm}{r^2}$ OR $\frac{mv^2}{r} = \frac{GMm}{r^2}$ OR $gR^2 = v^2 r = (\frac{2\pi r}{T})^2 r$	1M	
$r^3 = \frac{GM}{R^2} \times R^2 \times \frac{1}{\omega^2} = 9.81 \times (6.37 \times 10^6)^2 \times (\frac{24\times60\times60}{2\pi})^2$	1M	
$r = 4.222197 \times 10^7 \text{ m} \approx 42000 \text{ km}$		
	2	
6. (a) (i) $f = \frac{c}{\lambda}$		
$= \frac{3\times10^8}{675\times10^{-9}}$	1M	
$= 4.444444 \times 10^{14} \text{ Hz} \approx 4.44 \times 10^{14} \text{ Hz}$	1A	
	2	
(ii) $\frac{\sin 30°}{\sin\theta} = \frac{c}{v} = \frac{\lambda}{\lambda'}$		
$= \frac{675}{450}$	1M	
$\sin\theta = \left(\frac{450}{675}\right)\sin 30°$		
$\theta = 19.471° \approx 19.5°$	1A	
Definition: $n = \frac{\sin\theta_{air}}{\sin\theta_g}$	2	
(iii) The refractive index of glass for blue light is greater (than that for red light).	1A	
	1	
(b) (i) real and/or inverted	1A	
	1	
(ii) 10 cm	1A	
	1	

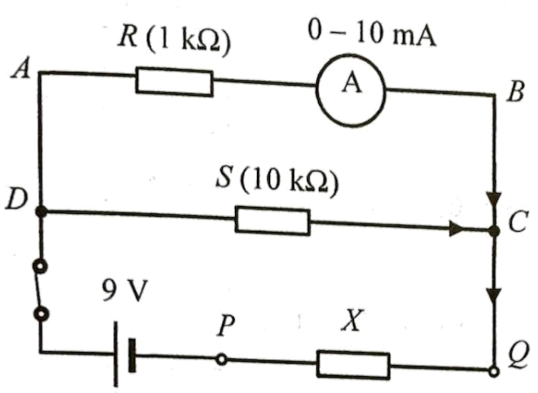
Solution	Marks	Remarks

6. (b) (iii)



Solution	Marks	Remarks
Location of F	1M	
Correct light rays from object to image	2M	
Correct position and size of image	1A	
Focal length of L = 9 cm	1A	Accept 8 cm to 10 cm
	5	
(iv) White light composes of different colours. Since the refractive indices of glass (the medium of the lens) are different for different colours,	1A	
the sizes of the colour images on the screen are slightly different. When these images overlap on the screen, colour edges are seen.	1A	
	2	

Solution	Marks	Remarks
7. (a) (i) Eddy currents are induced to oppose the change of magnetic flux due to the movement of the metal sheet.	1A	
Moving to the left → accept magnetic field	1A	
	2	
(ii) Kinetic energy → Electrical energy → Internal (heat/thermal) energy	2A	
	2	
(iii) Limitation: Eddy braking only works when the vehicle is moving. e.g. The vehicle cannot park in stationary positions / still on a slope.	1A	
	1	
(b) Electrical energy consumed $= 2\text{ kW} \times \frac{15}{60}\text{ h} = 0.5\text{ kW h}$	1M	
Cost $= \$\ 1.1 \times 0.5 = \$\ 0.55$	1A	
	2	
(c) Lamination, i.e. the cores of these devices are made up of multiple insulated sheets of metal.	1A	
	1	
(d) The magnetic field (produced by eddy currents) measured will decrease (where there are irregularities).	1A	
It is because the crack will reduce the eddy currents.	1A	
	2	

Solution	Marks	Remarks
8. (a) (i) $V_{AB} = (8.5 \times 10^{-3}\text{ A}) \times (1\text{ k}\Omega)$ $= 8.5\text{ V}$	1M 1A	
	2	
(ii) Current through $S = \dfrac{8.5\text{ V}}{10\text{ k}\Omega}$ $= 8.50 \times 10^{-4}\text{ A} = 0.85\text{ mA}$	1M 1A	As AB and CD are connected in parallel, current through S $= (8.5 \times 10^{-3}\text{ A}) \times \dfrac{1\text{ k}\Omega}{10\text{ k}\Omega}$
	2	
(iii) 	2A	
	2	
(iv) p.d. across $X = 9 - V_{AB} = 9 - 8.5 = 0.5\text{ V}$ Current through $X = (8.5 \times 10^{-3}) + (8.5 \times 10^{-4})$ $= 9.35 \times 10^{-3}\text{ A}$ Resistance of $X = \dfrac{0.5\text{ V}}{9.35 \times 10^{-3}\text{ A}}$ $= 53.476\ \Omega \approx 53.5\ \Omega$	1A 1M 1A	
	3	
(b) To prevent the ammeter from overloading (when PQ is shorted or the resistance to be measured is too small)	1A	
	1	

Solution				Marks	Remarks
9.	(a)	(i)	β decay / beta decay OR ${}^{40}_{19}\text{K} \rightarrow {}^{40}_{20}\text{Ca} + {}^{0}_{-1}\beta$	1A	
				1	
		(ii)	Justified: the penetrating power of β radiation enables it to penetrate the body's organ / skin Or Not justified: the activity is low and is comparable to background radiation / β radiation is largely shielded by the human body	1A	
				1	
	(b)	(i)	$\frac{0.45 \times 0.012\%}{40.0} = 1.35 \times 10^{-6}$ (mole)	1A	
				1	
		(ii)	$k = \frac{\ln 2}{1.25 \times 10^{9}\ (3.16 \times 10^{7})} = 1.754803 \times 10^{-17}\ (\text{s}^{-1})$	1M/1A	i. e. 5.545177×10^{-10} (year^{-1})
			Activity = kN $= 1.754803 \times 10^{-17} \times (1.35 \times 10^{-6} \times 6.02 \times 10^{23})$ $= 14.261284$ (Bq) ≈ 14.3 (Bq)	1A	Accept 14.2 to 14.3 (Bq)
				2	

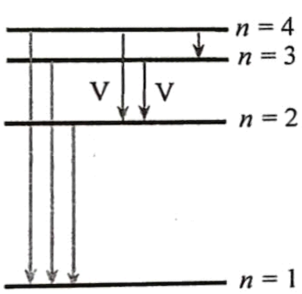
Section A : Astronomy and Space Science

1. B (54%)	2. B (52%)	3. D (53%)	4. C (62%)
5. A (46%)	6. D (44%)	7. A (39%)	8. D (34%)

Solution	Marks	Remarks
1. (a) (i) By definition: 1″ = 1 AU/1 pc Hence, the semi-major axis $a = 0.125'' \times 7940$ pc $= 992.5$ AU ≈ 993 AU	1A	
Or angular size $\theta = 0.125''$ $= \frac{0.125}{60\times60} \times \frac{\pi}{180°}$ $= 6.06 \times 10^{-7}$ rad $a = d \times \theta$ $= (7940 \times 206265) \times 6.06 \times 10^{-7}$ $= 992.5$ AU	1A	
	1	
(ii) Consider the Earth and the Sun, we have $a = 1$ AU, $M = M_S$ and $T = 1$ year. By simple ratio, $\frac{M_{\text{Sgr A*}}}{M_S} = \frac{(\frac{993\text{ AU}}{1\text{ AU}})^3}{(\frac{16.0\text{ yr}}{1\text{ yr}})^2} = 3.819017 \times 10^6 \approx 3.82 \times 10^6$ Hence the mass of the source is about $3.82 \times 10^6\ M_S$.	1M 1M	
	2	
(b) (i) Radial velocity v_r: measured by Doppler shift of spectral lines (emission / absorption lines) of star X. For positive v_r, the observed wavelength of the spectral features will be redshifted (larger wavelength or lower frequency) or blue shift (shorter wavelength or higher frequency) for negative v_r.	1A 1A	
	2	
(ii) At position D (around 2002). v_r is positive (away from the Earth) and increasing till 2002, which implies that (the massive force centre) Sgr A* is in position 2 (according to Kepler's second law) Or In 2002, star X experienced a sharp change in (radial) velocity / very large acceleration, from a large, positive v_r (away from the Earth) to a large, negative v_r (towards the Earth), indicating that it is close to Sgr A* (according to Kepler's second law), Sgr A* is therefore in position 2.	1A 1A	Accept: When X is closer to Sgr A*, it moves faster due to very large gravitational force.
	2	
(c) As escape velocity $v = \sqrt{\frac{2GM}{R}}$, we have $R = \frac{2GM}{v^2}$. Setting v as the speed of light c, radius of black hole $R_{BH} = \frac{2GM_{\text{Sgr A}^*}}{c^2}$ $= \left(\frac{2(1.33\times10^{20}\times3.82\times10^6)}{(3\times10^8)^2}\right)$ $= 1.129022 \times 10^{10}$ m $\approx 1.13 \times 10^{10}$ m ≈ 0.0752681 (AU) ≈ 0.075 (AU)	1M 1M 1A	
	3	

Section B : Atomic World

1. C (56%)	2. A (51%)	3. D (39%)	4. B (60%)
5. C (54%)	6. A (36%)	7. D (51%)	8. B (36%)

Solution	Marks	Remarks
2. (a) In the model the orbital electron gradually loses its energy (via radiation) and spirals inwards until it finally crashes into the nucleus, i.e. the atom collapses.	1A	
	1	
(b) (i) Line C (from $n = 5$ to $n = 2$)	1A	
	1	
(ii) $\lambda = 364.6\left(\dfrac{5^2}{5^2 - 2^2}\right)$		
$= 434.047619$ (nm) ≈ 434 (nm)	1A	
Colour – violet / blue / indigo	1A	
	2	
(iii) The incident photon is absorbed.	1A	
The hydrogen atom is ionized / becomes a hydrogen ion.	1A	
The orbital electron becomes a free electron, (i.e. liberated with some kinetic energy).	1A	
	3	
(iv) 	2A	
(Total number of spectral lines = 6)	1A	Two visible lines correctly marked.
	3	

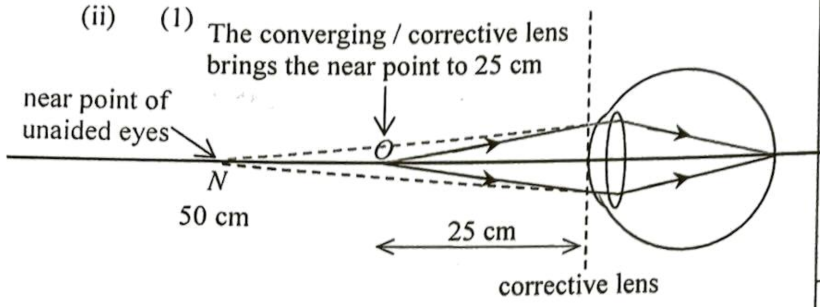
Section C : Energy and Use of Energy

1. C (73%)	2. D (61%)	3. B (66%)	4. C (49%)
5. A (55%)	6. C (74%)	7. B (50%)	8. A (64%)

Solution	Marks	Remarks
3. (a) The size of A is larger, more energy is used to overcome air resistance / friction. Or The mass of A is larger, more energy is dissipated in accelerating and/or decelerating the vehicle. (Accept reasonable factors relating to conversion efficiency)	1A	
	1	
(b) (i) 95×10^3 W h = 220 V $\times I \times$ 12 h	1M	
$I = 35.984848$ A $\approx$ 36.0 A	1A	Accept 35.9 A – 36.1 A
	2	
(ii) The charging efficiency is not 100% / energy is lost in the charging process (as heat / thermal energy).	1A	
	1	
(c) (i) Power out $= \frac{\frac{1}{2}mv^2}{t} = \frac{\frac{1}{2}\times2500\times(\frac{100}{3.6})^2}{5.5} \approx \frac{9.64506\times10^5}{5.5}$ $= 1.753648\times10^5$ W $\approx$ 175 kW	1M	
Efficiency $= \frac{175}{300}\times100\%$ $= 58.454920\% \approx 58.5\%$	1A	Accept 58% – 59%
	2	
(ii) Total time taken for maximum driving range test $= \frac{414}{70} = 5.914286$ h $\approx$ 5.91 h	1M	
Power output $= \frac{66}{5.91}$ $= 11.159420$ kW $\approx$ 11.2 kW	1A	Accept 11.0 kW – 11.5 kW
	2	
(d) Mode 2 (driving in a city with smooth traffic regulated by traffic lights) as (regenerative) braking can utilize the (relatively large) kinetic energy of the vehicle, say, when stopping at traffic lights.	1A+1A	
Or Mode 1 (driving at a few km per hour in often stop-and-go traffic conditions) as (regenerative) braking needs to be applied often.	0A+1A	
	2	

Section D : Medical Physics

1. D (51%)	2. B (39%)	3. A (27%)	4. C (49%)
5. A (51%)	6. C (54%)	7. D (73%)	8. B (59%)

Solution	Marks	Remarks
4. (a) (i) upper half Power $= \frac{1}{f} = -1.0\text{ D} \Rightarrow -1.0 = \frac{1}{\infty} + \frac{1}{-d}$ $\therefore$ Far point distance of unaided eyes $d = 1.0\text{ m} = 100\text{ cm}$	1A 1A/1M	$D_{eyeball}$ = diameter of eyeball Alternative method: $P_{eye} = \frac{1}{d} + \frac{1}{D_{eyeball}}$ (1) $P_{eye} - 1.0 = \frac{1}{\infty} + \frac{1}{D_{eyeball}}$ (2) (1 M)
	2	
(ii) (1) 	2A	
	2	
(2) With the corrective lens (convex lens), object at $O \Rightarrow u = 25\text{ cm} = 0.25\text{ m}$ virtual image at $N \Rightarrow v = -d$ (where d is the near point distance of unaided eyes) $P = \frac{1}{f} = \frac{1}{u} + \frac{1}{v}$ $\Rightarrow 2 = \frac{1}{0.25} + \frac{1}{-d}$ $\Rightarrow d = 0.5\text{ m} = 50\text{ cm}$	1M 1A	Alternative method: $P_{eye} = \frac{1}{d} + \frac{1}{D_{eyeball}}$ (1) $P_{eye} + 2 = \frac{1}{0.25} + \frac{1}{D_{eyeball}}$ (2) (1M)
	2	
(b) (i) $\Delta t = t_2 - t_1 = 8 - 3 = 5\ \mu\text{s}$ $d = \frac{1}{2}c\Delta t$ OR $d = ct'$ where $t' = \frac{\Delta t}{2}$ $= \frac{1}{2}(1520)(5 \times 10^{-6}) = 3.8 \times 10^{-3}\text{ m} = 3.8\text{ mm}$	1M 1A	Accept 4 μs to 5 μs Accept 3.04 mm ($\Delta t = 4$ μs) to 3.8 mm
	2	
(ii) The ultrasound pulses only need to detect structures near surface, absorption and attenuation are small. 15 MHz ($\lambda \sim 0.023$ mm) should be chosen as its wavelength is shorter than 3 MHz ($\lambda \sim 0.11$ mm), (spatial) resolution is higher.	1A	
	1	
(iii) Any ONE of the applications: - break up stones in kidney, gall bladder etc. - break down crystalline eye lens in cataract surgery - to remove calculus from surface of teeth in dentistry - high intensity ultrasound to destroy tumours (surgery) - speed up bone healing after a fracture. - therapeutic uses: reduce pain, increase circulation and increase mobility of soft tissues, reduce inflammation and healing of injuries and wounds.	1A	
	1	