Marking Scheme

This document was prepared for markers' reference. It should not be regarded as a set of model answers. Candidates and teachers who were not involved in the marking process are advised to interpret its contents with care.

General Marking Instruction

1. It is very important that all markers should adhere as closely as possible to the marking scheme. In many cases, however, candidates may have obtained a correct answer by an alternative method not specified in the marking scheme. In general, a correct answer merits ***the answer mark*** allocated to that part, unless a particular method has been specified in the question.

   In the marking scheme, alternative answers and marking guidelines are in | rectangles |.

2. In the marking scheme, answer marks or 'A' marks are awarded for a correct numerical answer with a unit. If the answer should be in km, then cm and m are considered to be wrong units.

3. In a question consisting of several parts each depending on the previous parts, method marks or 'M' marks are awarded to steps/methods or substitutions correctly deduced from previous answers.

4. The following symbol is used:

/	A single slash indicates an acceptable alternative within an answer.

5. In cases where a candidate answers more questions than required, the answers to all questions should be marked. However, the excess answer(s) receiving the lowest score(s) will be disregarded in the calculation of the final mark.

Paper 1 Section A

Question No.	Key	Question No.	Key
1.	B (54)	26.	C (42)
2.	B (49)	27.	C (59)
3.	C (53)	28.	C (42)
4.	D (48)	29.	D (42)
5.	A (44)	30.	B (40)
6.	D (56)	31.	A (43)
7.	A (25)	32.	C (46)
8.	D (41)	33.	B (49)
9.	D (64)	34.	A (76)
10.	D (61)	35.	B (56)
11.	B (48)	36.	B (63)
12.	A (52)		
13.	D (35)		
14.	A (82)		
15.	B (66)		
16.	B (71)		
17.	A (63)		
18.	D (52)		
19.	C (53)		
20.	C (64)		
21.	A (56)		
22.	C (40)		
23.	A (46)		
24.	D (53)		
25.	C (58)		

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

Paper 1 Section B

Marks

1. (a) $(1.5 \times 1000\text{ kg}) \times 4200\text{ J kg}^{-1}\,°\text{C}^{-1} \times (80 - 60)\,°\text{C} \times (1-15\%)$ — 1M+1M
$= 1.07 \times 10^{8}\text{ J}$ — 1A — 3

(b) $1.07 \times 10^{8}\text{ J} \div (4.5\text{ kW}) \div 3600\text{ s}$ — 1M
$= 6.61$ (hours) — 1A — 2

(c) Rate of heat transfer drops as the water temperature drops / the room temperature increases / temperature difference drops. — 1A — 1

2. (a) Stop heating and — 1A
stir the water well. — 1A — 2

(b) (i) $\dfrac{L-64}{80-64} = \dfrac{65-20}{92-20}$ — 1M

$L - 64 = 10$

$L = 74\text{ mm}$ — 1A — 2

(ii) Let x °C be the absolute zero.

$\dfrac{20-x}{92-20} = \dfrac{64-0}{80-64}$ — 1M

$20 - x = 288$

$x = -268\,°\text{C}$ — 1A — 2

3. (a) (i) $P = Fv$ — 1M

$= 8000\text{ N} \times 2\text{ m s}^{-1}$

$= 16\text{ kW}$ — 1A — 2

(ii) $P_{loss} = 20\text{ kW} - 16\text{ kW} = 4\text{ kW}$ — 1A — 1

(b) (i) $P = 4\text{ kW} + (8000 - 7000\text{ N}) \times 2\text{ m s}^{-1}$ — 1M

$= 6000\text{ W} = 6\text{ kW}$ — 1A — 2

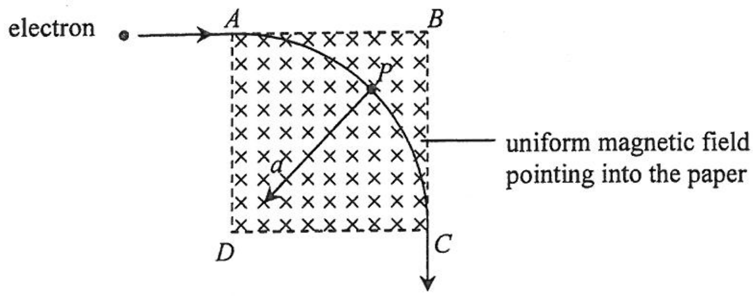
(ii) Output power required from motor is smaller. — 1A
Or Force exerted by motor is smaller. — 1

(iii) No, the lift system could not work / the lift will fall — 1A
as slipping would occur / the cable cannot be fixed on the drum / the drum cannot exert a force on the cable. — 1A — 2

4. (a) (i) $F = qvB = (1.60\times10^{-19}\text{ C})(1.2 \times 10^{7}\text{ m s}^{-1})(0.01\text{ T})$ — 1M

$= 1.92\times10^{-14}\text{ N}$ — 1A — 2

(ii)



1A — 1

				Marks	
4.	(b)		F is perpendicular to the electron's displacement / velocity, Or electron only changes direction while speed remains unchanged, no work is done, therefore k.e. remains unchanged.	1A 1A	 2
	(c)		$F = qvB = \dfrac{mv^2}{r}$ $\dfrac{v}{r} = \dfrac{qB}{m}$ = constant	1M	
			v should be halved, i.e. 0.6×10^7 m s^{-1}	1A	2
5.			Stick the paper strip onto the horizontal part BC of the track. Release the toy from a certain height h from the bench surface and measure the corresponding stopping distance d. Stopping distance should be measured from the beginning of the horizontal part BC or on the paper strip. Release the toy from different heights and measure the corresponding stopping distances.	1A 1A 1A	
			Plot a graph of d against h, a straight line passing through the origin should be obtained. or since $mgh = Fd$ so $\dfrac{d}{h}$ = constant / $d \propto h$	1A 1A	 5
6.	(a)	(i)	Accelerates at g before the elastic cord stretches / at the beginning. Acceleration decreases as the cord stretches. Decelerates until momentarily at rest (after the tension in the cord is greater than mg).	1A 1A 1A	 3
		(ii)	Gravitational potential energy changed to kinetic energy and (then) elastic potential energy in elastic cord.	1A 1A	 2
	(b)		Elastic cord lengthens the stopping time, hence reduces the (net) force acting on the player.	1A 1A	 2
	(c)		Contact area is larger, hence pressure is smaller during the fall and the structure is less likely to break / detach.	1A 1A	 2

Marks

7. (a) $c = f\lambda \Rightarrow 3 \times 10^8 \text{ m s}^{-1} = f(0.02 \text{ m})$ — 1M

$\therefore \quad f = 1.5 \times 10^{10}$ Hz or 15000 MHz — 1A — 2

(b) (i) Path difference of the diffracted waves from slits *A* and *B* to probe varies along *XY*. — 1A

Constructive and destructive interference occur alternately to give maxima and minima. — 1A — 2

(ii) $BP - AP = 1\frac{1}{2}\lambda$ — 1M

$BP - AP = 3 \text{ cm} = 0.03 \text{ m}$

$\therefore BP = 1.24 + 0.03 = 1.27 \text{ m}$ — 1A — 2

(iii) Path difference along $XY < AB$

$AB = 3 \times 2 \text{ cm} = 3\lambda$

$\therefore$ path difference allowed $= 0\lambda, 1\lambda, 2\lambda$. — 1M (for the three lines above)

Maximum number of maxima = 3 — 1A — 2

(c) Radio waves with lower frequencies (will have longer wavelengths and hence) have greater diffraction effect. — 1A

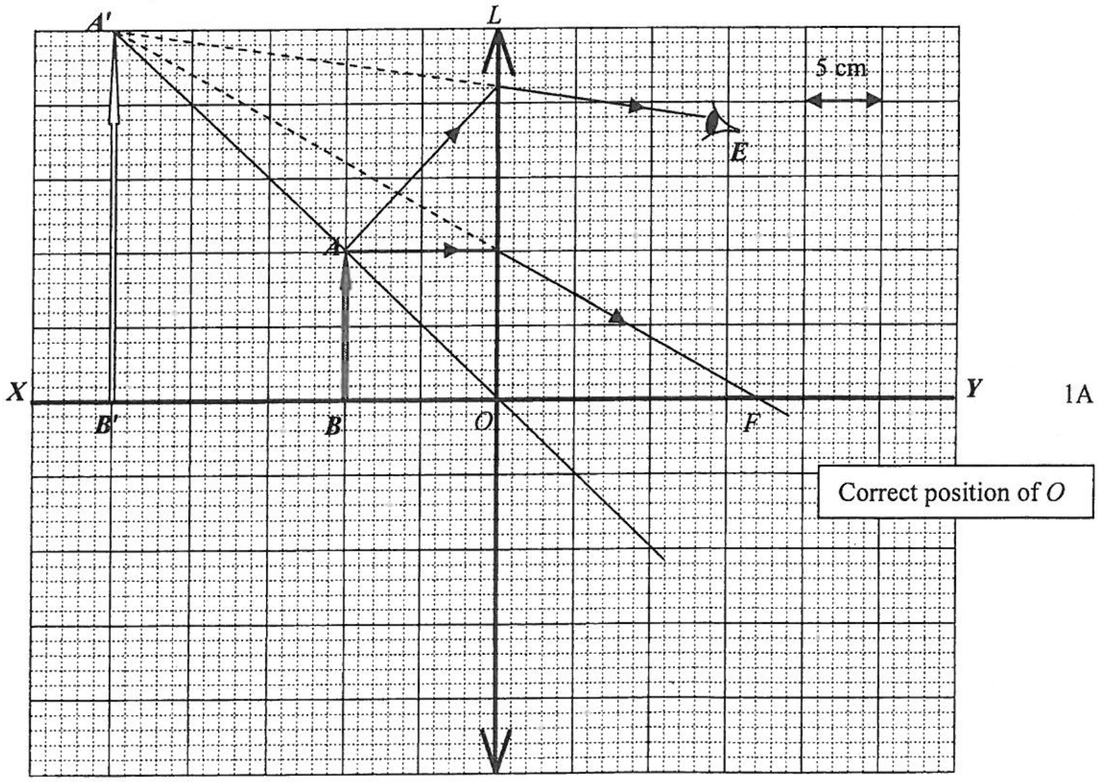
Radio waves by-pass small obstacles / not to be reflected from small obstacles. — 1A — 2

8. (a) (i) Virtual — 1A — 1

(ii) Convex. — 1A

Only convex lens can form magnified (virtual, erect) images. — 1A — 2

(b) (i)



1A — 1

(ii) Correct light ray to locate *F*. — 1M

Focal length $f = 17$ cm (16.0 to 17.5 cm) — 1A — 2

(c) Correct ray from *A'* or lens to *E*. — 1A

All correct. — 1A — 2

(d) Magnifying glass / glasses for long-sighted eyes / simple microscope — 1A — 1

Marks

9. (a)

$$k = \frac{\ln 2}{5730 \times 3.16 \times 10^{7}} = 3.83 \times 10^{-12}\,(\mathrm{s}^{-1})$$ 1A

Activity $A = kN$

$$N = \frac{A}{k} = \frac{0.2}{3.83 \times 10^{-12}}$$ 1M

$$= 5.22 \times 10^{10}$$ 1A 3

(b) No. of ^{14}C nuclei: $N_0 = 1 \times 10^{23} \times (1.3 \times 10^{-12}) = 1.3 \times 10^{11}$ 1A 1

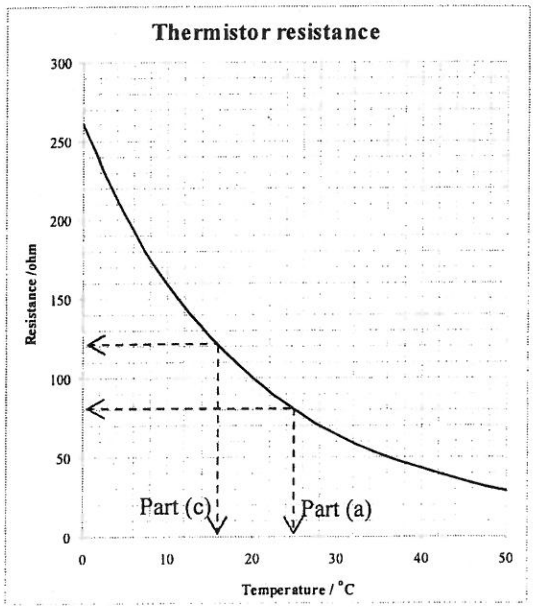
(c)

$$kt = \ln \frac{N_0}{N}$$

$$(3.83 \times 10^{-12})\ t = \ln \frac{1.3 \times 10^{11}}{5.2 \times 10^{10}}$$ 1M

$t = 2.4 \times 10^{11}$ s or 7571 (years) (accept 7500 to 7600 (years)) 1A 2

10. (a) (i) 80 Ω 1A 1



(ii)

$$V_{AB} = \frac{120}{(80 + 120)} 12$$ 1M

$$= 7.2\ \mathrm{V}$$ 1A 2

(b) As R_v and 120 Ω resistor are in parallel, R_{eq} across AB is smaller than 120 Ω, 1A
therefore voltage shared across AB is reduced / smaller than expected. 1A

Use a voltmeter with resistance much larger than the resistance in that part of the circuit. 1A
(e.g. 10 MΩ in some digital voltmeter) 3

(c) (i)

$$V_{AB} = \frac{120}{(R + 120)} \times 12 = 6.0\,\mathrm{V}$$

$R = 120$ Ω 1A

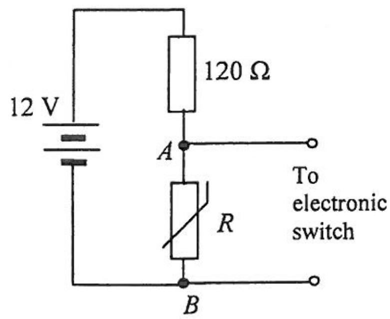
corresponds to temperature at 16°C. 1A 2

Marks

10. (c) (ii) Correct circuit (i.e. interchange thermistor R and 120 Ω resistor). — 1A

As the temperature drops, the thermistor resistance increases. — 1A

When the resistance increases to a value such that V_{AB} = 6.0 V or above, the electronic switch is on and it turns on the heating device. — 1A 3



11. (a)

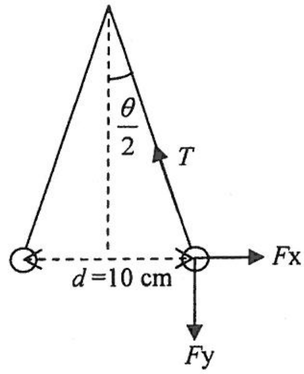
$$T\cos\frac{\theta}{2} = F_y = mg$$ — 1M

$$T\sin\frac{\theta}{2} = F_x = \frac{Q^2}{4\pi\varepsilon_0 d^2}$$ — 1M

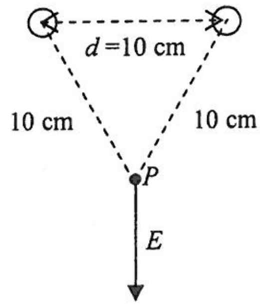
$$\tan\frac{\theta}{2} = \frac{Q^2}{4\pi\varepsilon_0 d^2}\left(\frac{1}{mg}\right)$$

$$= 9\times10^9\times\frac{(3.1\times10^{-9})^2}{0.1^2}\times\frac{1}{(1.0\times10^{-5})(9.81)}$$

$$\frac{\theta}{2} = 5.0° \text{ i.e. } \theta = 10.1°$$ — 1A 3



(b) (i)



1A 1

(ii) Potential at P $= \dfrac{Q}{4\pi\varepsilon_0 d} + \dfrac{Q}{4\pi\varepsilon_0 d} = \dfrac{2Q}{4\pi\varepsilon_0 d}$ — 1M

$$= (9\times10^9)\frac{2\times3.1\times10^{-9}}{0.1}$$

$$= 558 \text{ V}$$ — 1A 2

(iii) Separation d decreases. — 1A 1

Paper 2

Section A : Astronomy and Space Science

1. B(78%)	2. D(43%)	3. A(44%)	4. D(33%)
5. A(43%)	6. B(56%)	7. C(61%)	8. C(46%)

Marks

1. (a) Satellites will be directly above a certain location on the equator of the Earth, with period = 24 hrs same as that of the Earth, — 1A

thus enables easy transmitting / receiving signals from the Earth / no altering of aerial for tracking the satellite is required. — 1A — 2

(b) $\frac{mv^2}{r}=\frac{GMm}{r^2}$ — 1M

$v=\sqrt{\frac{GM}{r}}=\sqrt{\frac{4.0\times10^{14}}{(6.4\times10^6+0.3\times10^6)}}$

$=7727\text{ m s}^{-1}$ — 1A — 2

(c) (i) Total energy $=\frac{1}{2}mv^2+(\frac{-GMm}{r})$ — 1M

$=\frac{GMm}{2r}+(\frac{-GMm}{r})=\frac{-GMm}{2r}$ $\quad(\frac{mv^2}{r}=\frac{GMm}{r^2}$ i.e. $\frac{mv^2}{2}=\frac{GMm}{2r})$ — 1M — 2

(ii) $\Delta E=\frac{-GMm}{2}(\frac{1}{r_B}-\frac{1}{r_A})=\frac{1}{2}(4.0\times10^{14})(2000)(\frac{1}{6700}-\frac{1}{42400})\times10^{-3}$ — 1M

$=5.03\times10^{10}$ J — 1A — 2

(iii) Kepler's third law for elliptical orbit $T^2=\frac{4\pi^2a^3}{GM}$

$a=[r_A+r_B]\div2$

$=\frac{6.7\times10^6+42.4\times10^6}{2}$ m

$=2.455\times10^7$ m — 1M

Time from A to B $=\frac{T}{2}=\frac{1}{2}\sqrt{\frac{4\pi^2a^3}{GM}}=\frac{2\pi}{2}\sqrt{\frac{a^3}{GM}}=\pi\sqrt{\frac{(2.455\times10^7)^3}{4.0\times10^{14}}}$

$=19107$ s $=318.5$ min / 5.3 hrs — 1A — 2

{Or : $T^2\propto a^3$

$(\frac{T}{24})^2=[\frac{(6700+42400)\div2}{42400}]^3$

$T=10.6$ hrs $\Rightarrow t=5.3$ hrs}

Section B : Atomic World

1. D(50%)	2. C(42%)	3. C(49%)	4. D(44%)
5. A(64%)	6. B(73%)	7. B(22%)	8. A(44%)

Marks

2. (a) (i) $E = hf$ = work function + KE_{max} 1A 1
$= 2.30 \text{ eV} + 0.81 \text{ eV} = 3.11 \text{ (eV)}$

(ii) Only those conduction / free electrons at the surface can have the maximum kinetic energy. 1A
Or The work function of a metal is only the minimum energy required to eject an electron.
Or The conduction / free electrons in metal have different energies.
Or Less energetic electrons are tightly bound to the nuclei and require more energy to break free of its attraction to the nuclei.
Or Some electrons are not at the surface of metal so don't have maximum kinetic energy. 1

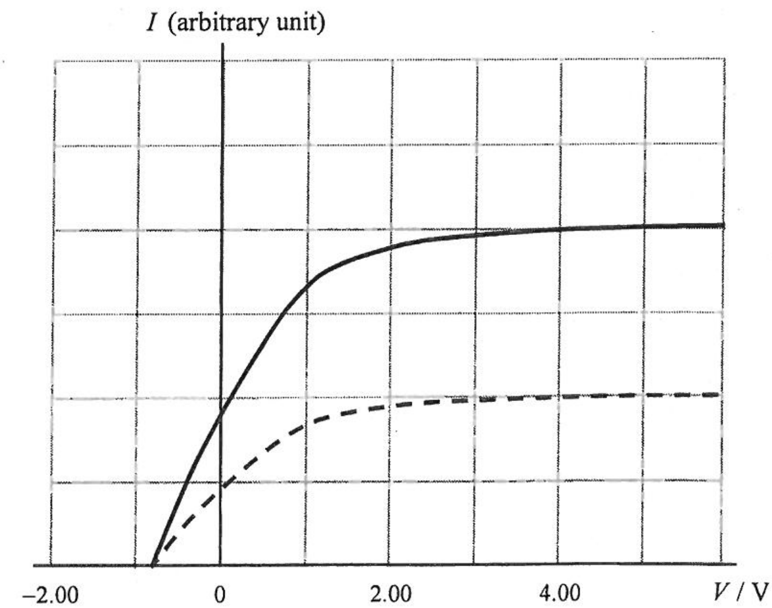
(b) (i) Energy absorbed by an atom = work function
$(0.01 \text{ W m}^{-2}) \times [0.01 \times (10^{-9})^2 \text{ m}^2] \times t \text{ s} = 2.30 \times (1.60 \times 10^{-19}) \text{ J}$ 1M
$t = 3680 \text{ s} = 61.3 \text{ min.}$ 1A 2

(ii) If a single photon has sufficient energy to knock out an electron, the electron gains enough energy in just one collision. 1A
Or It is a one-to-one process / an electron can be ejected instantaneously if it accepts a photon of energy larger than the work function of the metal. 1

(c) $(0.01 \text{ W m}^{-2}) \times (4.00 \times 10^{-4} \text{ m}^2) \div [3.11 \times (1.60 \times 10^{-19}) \text{ J}]$
$= 8.04 \times 10^{12}$ (photons per second) 1A

$(8.04 \times 10^{12}) \times 0.1 \times (1.60 \times 10^{-19}) \text{ A}$ 1M
$= 1.29 \times 10^{-7} \text{ A} = 0.13 \text{ µA}$ 1A 3

(d)



2A

2

Section C : Energy and Use of Energy

1. A(55%)	2. B(75%)	3. C(78%)	4. D(56%)
5. B(59%)	6. D(30%)	7. A(71%)	8. C(55%)

Marks

3. (a) $2000\left[\frac{1}{4\pi(3.4)^2}\cos^3(\tan^{-1}(\frac{1.2}{3.4}))\right]$ 1M

$= 11.5$ (lm m^{-2}) 1A 2

(b) Rough surface should be used such that 1A

reflection becomes diffuse to reduce glare. 1A 2

(c) (i) 14.5 kW + 15 × 0.1 kW + 6 × 0.08 kW 1M

= 16.48 (kW) (accept 16.48 kW or 16.5 kW) 1A 2

(ii) (6 × 0.1 kW + 16.48 kW × 50%) 1M

× 8 × 20 × 1.0 1M

= $ 1414.4 (accept $ 1414.4 or $1416) 1A 3

(iii) Windows with low-e coating. 1A

Or Thicker walls.

Or Replace light bulb by fluorescent lamp.

Or Replace air-conditioner with higher cooling capacity / COP. 1

Section D : Medical Physics

1. A(47%)	2. C(59%)	3. C(38%)	4. A(41%)
5. D(37%)	6. B(36%)	7. B(53%)	8. D(77%)

Marks

4. (a) (i) 2.25 cm — 1A 1

(ii) $x_{½} = \frac{\ln 2}{\mu}$ (or $0.5I_0 = I_0 e^{-\mu x_{½}}$) — 1M

$0.0225 = \frac{\ln 2}{\mu}$

$\mu = 30.8\ \text{m}^{-1}$ (accept $30.8\ \text{m}^{-1}$ and $31.0\ \text{m}^{-1}$) — 1A 2

(iii) Medium *Q*: lower density — 1A 1

(b) (i) Intensity of X-rays is attenuated / absorbed when they pass through a medium. — 1A
The attenuation / absorption in bone is greater than that in soft tissue. Therefore the film appears lighter under bone / darker under soft tissue. — 1A 2

(ii) The X-ray tube and detectors rotate round the patient to take multiple X-ray projections / images. — 1A
The projections are used to reconstruct /compute / make back projection /combine to form tomographs which contain more information of the body. — 1A 2

(iii) - radiation exposure or dosage is much higher for CT scan (8.0 mSv Vs 0.01 mSv for X-ray imaging) — 1A
- not as mobile or easily accessible as X-ray imaging — 1A 2

Candidates' Performance

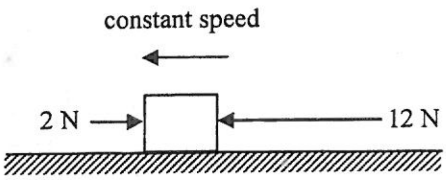
Paper 1

Paper 1 consists of two sections, multiple-choice questions in Section A and conventional questions in Section B. All questions in both sections are compulsory.

Section A (multiple-choice questions)

Section A consisted of 36 multiple-choice questions and the mean score was 19. Candidates' performance in the following items revealed some of their weaknesses:

7.

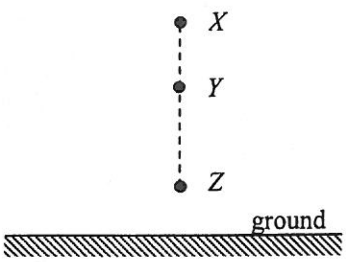


A block on a rough horizontal surface is moving to the left with constant speed under two horizontal forces 2 N and 12 N indicated as shown. If the force of 12 N is suddenly removed, what is the net force acting on the block at that instant ?

* A.	12 N	(25%)
B.	10 N	(15%)
C.	8 N	(26%)
D.	2 N	(34%)

Only one quarter of the candidates identified the correct answer as Option A, which suggests that a majority of candidates did not realise that friction applies as long as the block is still moving.

8.

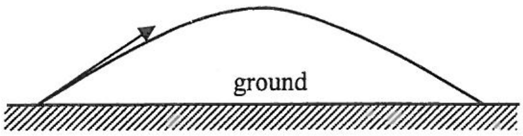


A particle is released from rest at X as shown. It takes time t_1 to fall from X to Y and time t_2 to fall from Y to Z. If $XY : YZ = 9 : 16$, find $t_1 : t_2$. Neglect air resistance.

A.	2 : 3	(10%)
B.	3 : 4	(37%)
C.	4 : 3	(12%)
* D.	3 : 2	(41%)

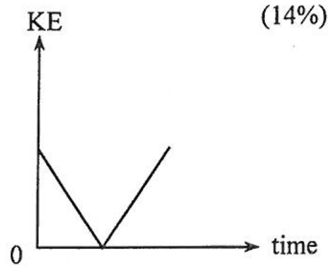
It seems that candidates were not competent in using the formula $s = \frac{1}{2}gt^2$ to tackle this problem.

13.

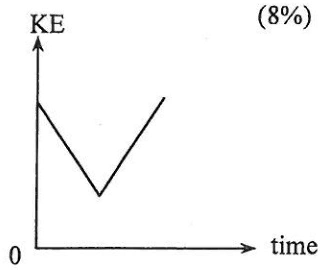


A particle is projected into the air at time $t = 0$ and it performs a parabolic motion before landing on the ground as shown. Which graph represents the variation of the kinetic energy (KE) of the particle with time before landing ? Neglect air resistance.

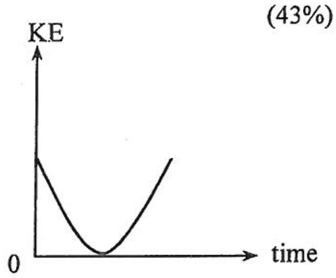
A. (14%)



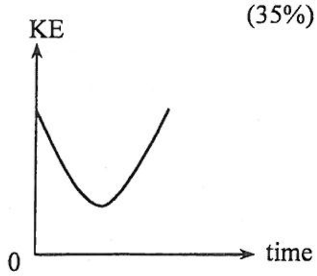
B. (8%)



C. (43%)

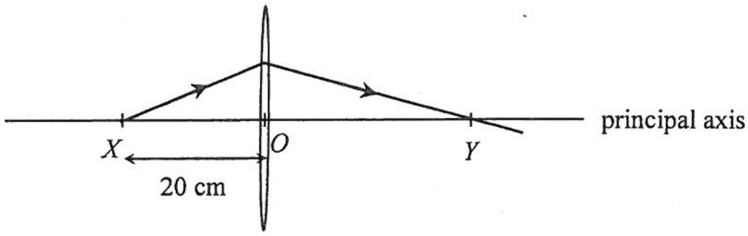


* D. (35%)



More than half of the candidates did not realise that the particle still has kinetic energy when it flies horizontally at the highest point.

22.



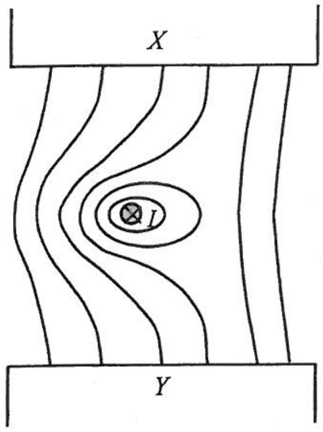
A point light source at X on the principal axis of a thin convex lens emits a ray of light. The ray passes through the lens and reaches the principal axis at point Y as shown. O is the optical centre of the lens such that $OX = 20$ cm and $OY > OX$. Which of the following statements is/are correct ?

(1) The focal length of the lens is shorter than 20 cm.
(2) If the point light source is shifted away from the lens, separation OY would increase.
(3) An object placed at Y would give a diminished image at X.

A.	(1) only	(23%)
B.	(2) only	(19%)
* C.	(1) and (3) only	(40%)
D.	(2) and (3) only	(18%)

About 40% of the candidates did not demonstrate a full understanding of the concept of reversibility of light.

26.

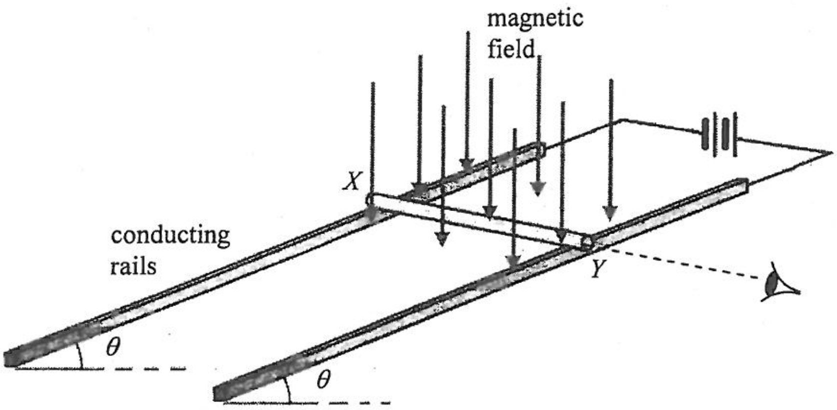


A straight wire carrying current I pointing into the paper is placed in a magnetic field between pole pieces X and Y. The figure shows the resultant field line pattern. What is the polarity of pole piece X and in what direction is the magnetic force acting on the wire ? Ignore the effect of the Earth's magnetic field.

	polarity of X	direction of magnetic force	
A.	N	to right	(14%)
B.	N	to left	(29%)
* C.	S	to right	(42%)
D.	S	to left	(15%)

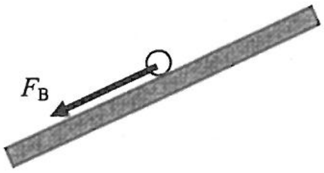
More than half of the candidates identified the correct polarity although some of them made mistakes in the direction of magnetic force.

28.

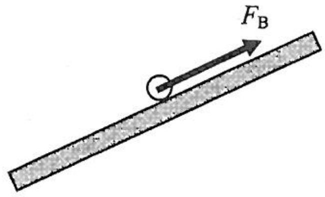


A copper rod XY is placed on a pair of smooth inclined conducting rails which are located in a magnetic field applied vertically downward. The rails make an angle θ to the horizontal and a battery is connected to the rails as shown above. Which diagram shown below represents the magnetic force F_B acting on the rod when viewed from end Y?

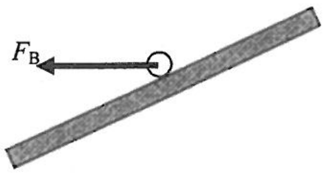
A. (23%)



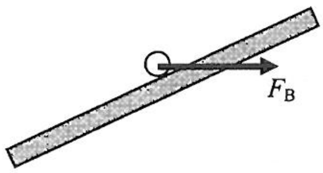
B. (13%)



* C. (42%)



D. (22%)



More than 30% of the candidates did not realise that the magnetic force F_B must be perpendicular to the magnetic field.

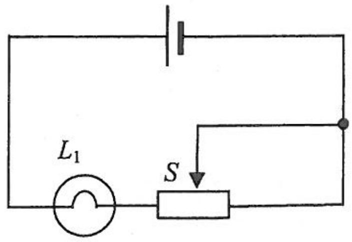
29.

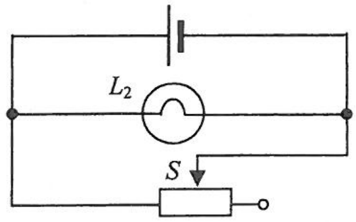
A metal rod OP is rotated about O in a clockwise direction in the plane of the paper with a uniform magnetic field pointing into the paper. Which statement is correct?

A.	An induced current flows in the rod from O to P.	(18%)
B.	An induced current flows in the rod from P to O.	(14%)
C.	E.m.f. is induced in the rod with end O at a higher electric potential.	(26%)
* D.	E.m.f. is induced in the rod with end P at a higher electric potential.	(42%)

More than 30% of the candidates wrongly thought that an induced current could flow in an incomplete circuit.

31.



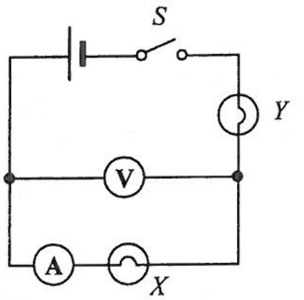


In each of the above circuits, the cell has constant e.m.f. and negligible internal resistance. When the sliding contact S of each rheostat shifts from the mid-position to the right, how would the brightness of each bulb change ?

	bulb L_1	bulb L_2	
* A.	becomes dimmer	remains unchanged	(43%)
B.	becomes dimmer	becomes brighter	(29%)
C.	remains unchanged	becomes dimmer	(17%)
D.	becomes brighter	remains unchanged	(11%)

More than 40% of the candidates failed to realise that the brightness of L_2 would not be affected by the change in resistance of S in the parallel branch.

32.



In the above circuit, the cell has negligible internal resistance. When switch S is closed, both bulbs are not lit. The voltmeter has a reading but the ammeter reads zero. If only one fault has been developed in the circuit, which of the following is possible ?

A.	Bulb X has been shorted accidentally.	(15%)
B.	Bulb Y has been shorted accidentally.	(15%)
* C.	Bulb X is burnt out and becomes open circuit.	(46%)
D.	Bulb Y is burnt out and becomes open circuit.	(24%)

It seems that more than half of the candidates did not fully understand the meaning of short circuit and open circuit.