

MARKING KEY
Sample examination
Stage 3
Physics

DRAFT

PHYSICS

Section one: Short answer

Question 1

Spectra

Description	Mark
A torch and B laser	1
laser light is monochromatic ie one frequency only unlike a incandescent filament	1

Question 2

Gravity on Everest

Description	Mark
A	1
Explanation can be verbal and/or mathematical, e.g. g at any point depends on the square of the distance from that point to the centre of the earth (g is proportional to $\frac{1}{r^2}$).	1
The height of Mt Everest (about 9000 m) is very much less than the radius of the Earth. The two distances are about 6 409 000 m and 6 400 000 m, and so g will be not very different from what it is at sea level. ($g_{\text{Everest}} = 99.7\% g_{\text{sea level}}$)	1

Question 3

Quasars

Description	Mark
Large redshift means that the object is receding from us at high speed	1
Hubble's law suggests that high recession rates mean great distances	1

Question 4

Screwdrivers

Description	Mark
Q is better	1
there is a greater torque for the same applied force as torque is proportional to the radius of the handle $\tau = r \times F$	1

Question 5(a)

Orbital velocity

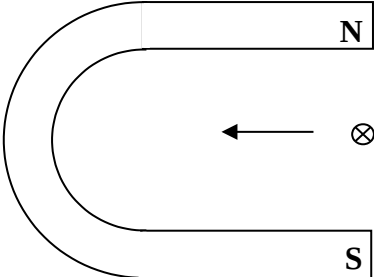
Description	Mark
$v = \frac{2\pi r}{T}$	1
$= \frac{2\pi(1.85 \times 10^6)}{119(60)} = 1.63 \times 10^3 \text{ m s}^{-1}$	1

Question 5(b)

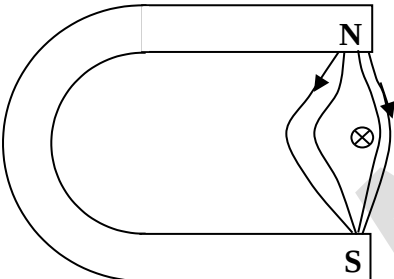
Moon mass

Description	Mark
$F = \frac{mv^2}{r} = \frac{Gmm_m}{r^2}$	1
$m_m = \frac{v^2 r}{G} = \frac{(1.63 \times 10^3)^2 (1.85 \times 10^6)}{6.67 \times 10^{-11}} = 7.35 \times 10^{22} \text{ kg}$	1

Question 6(a)
Magnet

Description	Mark
	1

Question 6(b)
Magnetic field

Description	Mark
	1

Question 7(a)
Enclose magnetic flux

Description	Mark
Plane of the rim must be vertical	1
and in the east-west direction	1

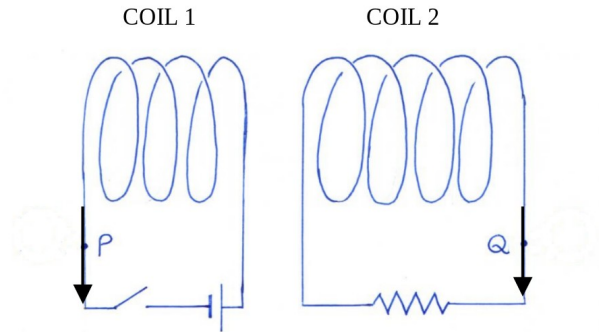
Question 7(b)
Estimate magnetic flux

Description	Mark
Reasonable estimate of radius of wheel eg 0.3 m	1
$\Phi = B A$	1
$= 55 \times 10^{-6} \times \pi \times 0.3^2 \text{ Wb}$ $= 2 \times 10^{-5} \text{ Wb}$	1

Question 8
Waves in a pulse

Description	Mark
frequency is number of pulses or vibrations each second	1
substitute time to be $0.10 \mu\text{s}$, so number is $[3.3 \times 10^9] \times 0.1 \times 10^{-6} = 330$	1


Question 9(a)
Induced current

Description		Mark
 <p>Current in coil 1 1 mark Current in coil 2 1 mark</p>		2

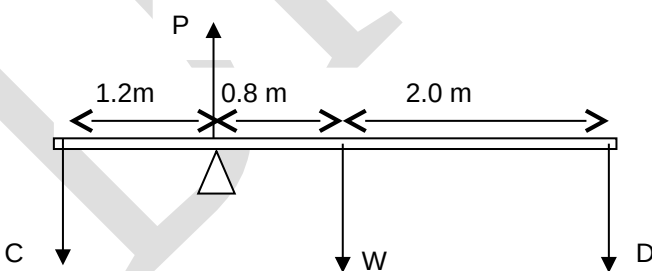
Question 9(b)
Current change

Description	Mark
It decreases to zero	1

Question 10(a)
Directions of forces

Description	Mark
 <p>1 mark for each correct arrow</p>	2

Question 10(b)
Magnitudes of forces

Description	Mark
 <p>Board is in equilibrium therefore $\Sigma \text{CWM} = \Sigma \text{ACWM}$ Taking moments about P: $W(0.8) + D(2.8) = C(1.2)$ $(120)(9.8)(0.8) + (62.5)(9.8)(2.8) = C(1.2)$ $C = 2.21 \times 10^4 \text{ N}$</p>	1
$\Sigma F_{\text{up}} = \Sigma F_{\text{down}}$ $P = C + W + D$ $= 2.21 \times 10^4 + 120(9.8) + 62.5(9.8)$ $= 4.00 \times 10^3 \text{ N}$	1

Question 11
Particle motion in magnetic field

Description	Mark
<p>Directions of paths of Q, R = 1 each = 2 marks Relative curvature = 1 mark</p>	3

Question 12
Free body diagram and force calculation

Description	Mark
	1
<p>For equilibrium: $\Sigma F = 0$ $\therefore \Sigma F_{\text{left}} = \Sigma F_{\text{right}}$</p>	1
<p>$T_{\text{leg}} = 2 T_{\text{rope}} \cos 37^\circ$ $= 2 \times 20 \times 9.8 \cos 37^\circ$ $= 313 \text{ N } (=310 \text{ N})$</p>	1

Question 13
Gravitational null point

Description	Mark
	1

$g_E = g_m$ $\frac{Gm_E}{r^2} = \frac{Gm_M}{r^2}$ $\frac{m_E}{(R-d)^2} = \frac{m_M}{d^2}$ $\frac{m_E}{m_M} = \frac{(R-d)^2}{d^2}$	1
$\frac{5.98 \times 10^{24}}{7.34 \times 10^{22}} = \left(\frac{R-d}{d} \right)^2$ $\sqrt{81.4} = \frac{R-d}{d}$ $\frac{d}{R-d} = \frac{1}{9}$ $\therefore \frac{d}{R} = \frac{1}{10} = 10\%$	1

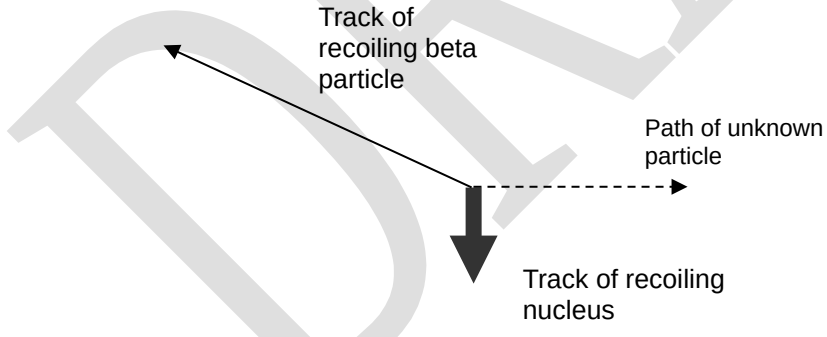
Question 14

Cancelling electric and magnetic fields

Description	Mark
Electric force given by $F = Eq$ and magnetic force given by $F = qvB$	1
In order to cancel these must be numerically equal i.e. $Eq = qvB$	1
Hence $v = \frac{Eq}{qB} = \frac{E}{B}$	1

Question 15

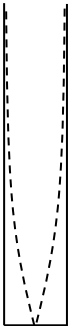

Evidence for neutrinos

Description	Mark
<p>To conserve momentum something must recoil approximately as shown</p> 	1
This particle does not produce visible tracks so is unlikely to be charged or to have a mass comparable to an electron mass.	1

Section two: Problem-solving

Question 16(a)

Fundamental and harmonic

Description		Mark
Fundamental		1
Next possible harmonic		1
Chimney is open at one end and closed at the other		1
Open end is a displacement antinode, closed end is a displacement node		1

Question 16(b)

Length of chimney

Description		Mark
Assume that speed of sound in air is 342 m s^{-1}		1
$v = f\lambda$		1
$\lambda = \frac{v}{f} = \frac{342}{30} = 114 \text{ m}$		1
Open pipe so length = $\frac{1}{4}\lambda = \frac{114}{4} = 28.5 \text{ m}$		1

Question 17(a)(i)

Electron transitions

Description		Mark
Completed all 6 transitions to high degree of accuracy or		2
Has at least three transitions correctly identified, correct arrow direction		1
maximum		2

Question 17(a)(ii)

Electron transition calculation

Description		Mark
$\Delta E_{3 \rightarrow 1} = \frac{hc}{\lambda}$		1
$= \frac{(6.63 \times 10^{-34})(3 \times 10^8)}{102.6 \times 10^{-9}} = 1.939 \times 10^{-18} \text{ J}$		1

Question 17(b)(i)
Phenomenon

Description	Mark
Fluorescence	1

Question 17(b)(ii)
Occurrence

Description	Mark
Atom excited by UV light to a higher energy level	1
Electrons drop to the ground state in a series of transitions.	1
At least one of these transitions emits coloured light.	1

Question 17(b)(iii)
Colour of rabbit

Description	Mark
Peak wavelength of emitted light is about 510 nm.	1
This corresponds to green light—from spectrum chart at beginning of question 17	1

Question 18(a)
Slip rings

Description	Mark
Enables alternating current to be withdrawn from the generator. Maintains constant contact between a particular side of the coil and a given terminal for the external circuit. [Students should indicate this on the diagram.]	1

Question 18(b)(i)
Graph of emf

Description	Mark
sinusoidal output	1
Period shown correctly	1

Question 18(b)(ii)
Graph of new emf

Description	Mark
Voltage is doubled	1
Period is halved	1

Question 18(c)(i)
Emf calculation

Description	Mark
3000 rpm = 50 Hz	1
Using 'quarter turn' method $A = 0.14 \times 0.09 = 0.0126 \text{ m}^2$ and $t = 0.005 \text{ s}$	1
$V = -N \frac{(\Phi_2 - \Phi_1)}{t} = -N \frac{B(A_2 - A_1)}{t} = -200 \frac{0.15(0 - 0.0126)}{0.005} = 76 \text{ V}$	1

Question 18(c)(ii)
Maximum or average

Description	Mark
This is an 'average' voltage. (student's statement must agree with the method used) [Maximum voltage would be given by $NAB(2\pi f)$] OR (Students can also calculate rms value given by $\sqrt{2}\pi BANf$)	1

Question 18(d)**Ways to increase emf: any two of**

Description	Mark
Number of turns can be increased, increasing the length of the wire in the coil	2
Magnetic field can be increased, greater magnetic fields produce greater induced emfs	2
Area of coil can be increased, greater area means the flux change is greater.	2
maximum	4

Question 19(a)(i)**Wavelength calculation**

Description	Mark
$E = hf = \frac{hc}{\lambda}$	1
$\lambda = \frac{hc}{E} = \frac{6.626 \times 10^{-34} \times 3 \times 10^8}{2.3 \times 10^6 \times 1.6 \times 10^{-19}}$ $= 5.40 \times 10^{-13} \text{ m}$	1

Question 19(a)(ii)**spectrum**

Description	Mark
X-rays (It is acceptable to have gamma rays).	1

Question 19(b)**Using radiation**

Description	Mark
Yes	1
Short wavelength means it penetrates solids well	1
More radiation would pass through a crack so highlighting its presence	1

Question 19(c)(i)**Radius of circle**

Description	Mark
$KE = \frac{1}{2} m v^2 \Rightarrow v = \sqrt{\frac{2E}{m}}$	1
$r = \frac{mv}{qB} = m \sqrt{\frac{\frac{2E}{m}}{qB}}$	1
$r = \sqrt{\frac{2 \times 1.67 \times 10^{-28} \times 2.3 \times 10^6 \times 1.6 \times 10^{-19}}{1.6 \times 10^{-19} \times 0.35}}$ $= 198 \text{ mm}$	1

Question 19(c)(ii)**Radius change**

Description	Mark
If kinetic energy increases then speed increases	1
From the formula $r = \frac{mv}{qB}$, then radius would increase	1

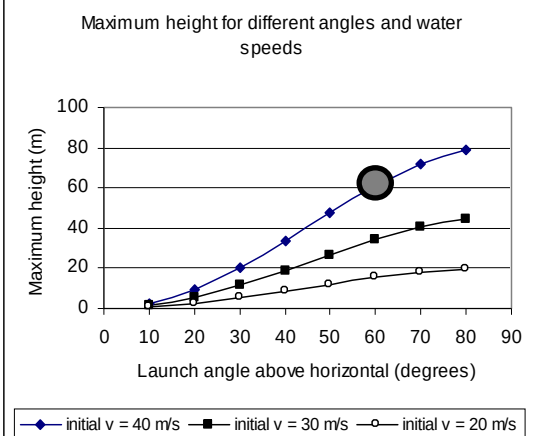
Question 20(a)
Maximum height and range

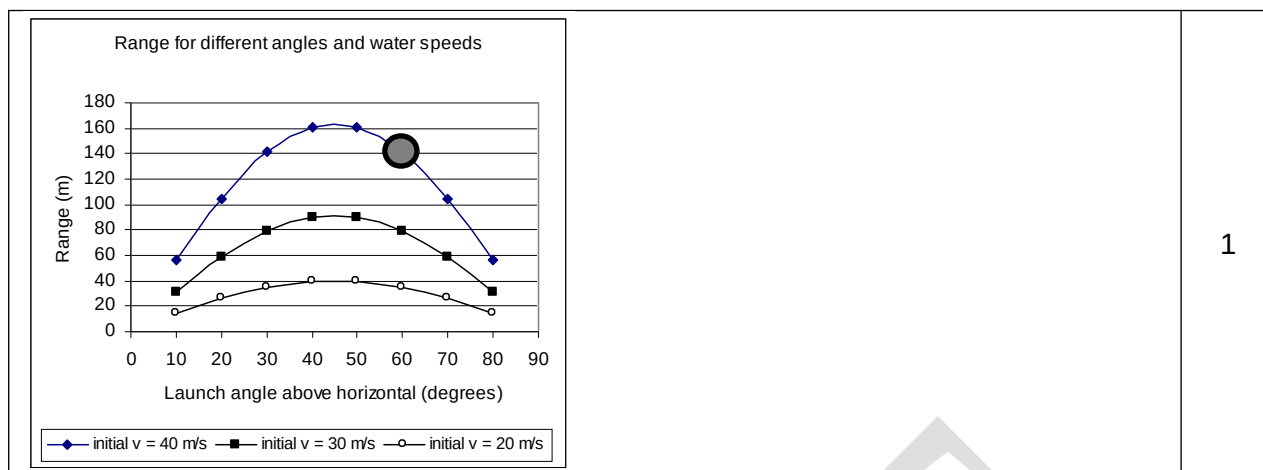
Description	Mark
$v_H = 40 \cos 60^\circ \quad v_V = 40 \sin 60^\circ$	1
$v^2 = u^2 + 2as$ $s = h = \frac{v^2 - u^2}{2g} = \frac{0 - (40 \sin 60^\circ)^2}{2 \times (-9.8)} = 61.2 \text{ m} \quad (\text{max height above nozzle})$	1
$v = u + at$ $\therefore t = \frac{v - u}{g} = \frac{0 - 40 \sin 60^\circ}{-9.8} = 3.53 \text{ s}$ $v = \frac{s}{t}$ $s = R = v_H t = 40 \cos 60^\circ \times 2 \times 3.53 = 141 \text{ m} \quad (\text{range})$	1

Question 20(b)
Helicopter height

Description	Mark
Horizontal: $s_H = 150 \text{ m} \quad v_H = 22 \text{ m s}^{-1} \quad v = \frac{s}{t}$	1
hence $t = \frac{s_H}{v_H} = \frac{150}{22} = 6.82 \text{ s}$	1
Vertical: $s = ut + \frac{1}{2}at^2 = 0 + \frac{1}{2}(9.8)(6.82)^2 = 228 \text{ m} (= \text{minimum height})$	1

Question 20(c)(i)
Height and range from graph

Description	Mark
	1



Question 20(c)(ii)
Angles and speed

Description	Mark
Best angle = 60° Best velocity = 30 m s ⁻¹	1
Explanation may include any of the following: Maximum height should be around 35 m Launch speed = 20 m s ⁻¹ won't reach required height Launch speed = 30 m s ⁻¹ but angles ≤ 50° and ≥ 60° won't reach required height Launch speed = 40 m s ⁻¹ at angle of 70-80° is possible but reaches too great a height	1

Question 21(a)(i)
Distance travelled

Description	Mark
Distance = v.T	1


Question 21(a)(ii)
Number of particles

Description	Mark
number of particles in a length $\ell = \frac{n}{\ell}$	1
number of particles in a length $v.T = \frac{nvT}{\ell}$	1

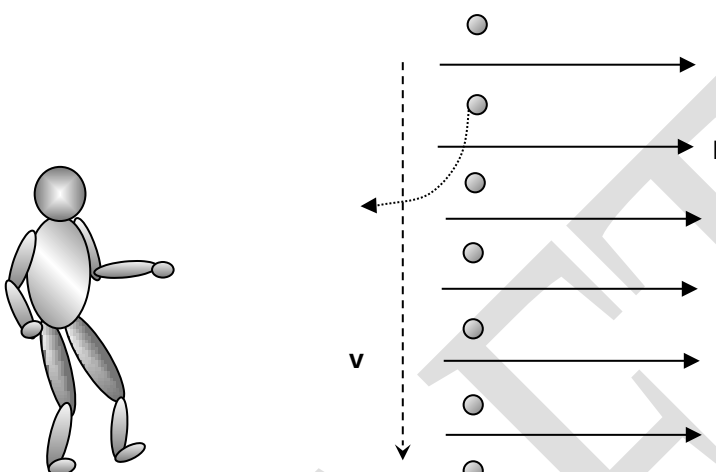
Question 21(b)
Current equivalence

Description	Mark
charge on particles (in a length ℓ) = $Q \left(\frac{nvT}{\ell} \right)$	1
current = $\frac{\text{charge}}{\text{time}} = \frac{Q}{T}$	1
but charge = $Q \left(\frac{nvT}{\ell} \right)$ $\therefore I = \frac{Q \left(\frac{nvT}{\ell} \right)}{T} = \frac{vnQ}{\ell}$	1

Question 21(c)(i)
Direction of electric force

Description	Mark
to the left, eg 	1

Question 21(c)(ii)
Particle path

Description	Mark
 <p>Observer</p> <p>Path curves clockwise as shown</p>	1

Question 21(d)(i)
Magnetic field direction

Description	Mark
Out of the page or	2
Into the page	1

Question 21(d)(ii)
Magnetic force equivalence

Description	Mark
since $v = \frac{\ell}{T}$, $\therefore BvQ = \frac{B\ell Q}{T}$	1
$BvQ = \frac{B\ell Q}{T} = B\ell \left(\frac{Q}{T} \right)$	1
but $\frac{Q}{T} = I$ $\therefore BvQ = B\ell I = I\ell B$	1

Section three: Comprehension

Question 22(a)

Resonant frequency of bubbles

Description	Mark
$f_0 = \frac{1}{2\pi} \sqrt{\frac{3\gamma P_0}{\rho R_0^2}}$	1
$= \frac{1}{2\pi} \sqrt{\frac{3(1.4)(100 \times 10^3)}{(1 \times 10^3)(3 \times 10^{-3})^2}}$	1
$\approx 1100 \text{ Hz}$	1

Question 22(b)(i)

Cavitation location

Description	Mark
$f = \frac{300}{60} = 5 \text{ Hz}$ $v = 14 \text{ m s}^{-1}$	1
$v = \frac{2\pi r}{T} = 2\pi r f$	1
$r = \frac{v}{2\pi f} = \frac{14}{2\pi(5)} = 0.45 \text{ m}$ i.e. 0.45 m along blade from centre.	1

Question 22(b)(ii)

Cavitation damage

Description	Mark
The tips of the blades or where water speed (relative to blade) is greatest	1

Question 22(c)(i)

Snapping shrimp bubbles

Description	Mark
From figure 1: radius $\approx 3.5 \text{ mm}$	1

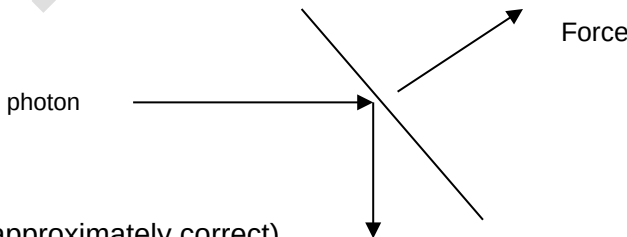
Question 22(c)(ii)

Bubble collapse time

Description	Mark
From either figure: time $\approx 0.3 \text{ ms}$	1

Question 23(a)

Photon momentum

Description	Mark
Photons have momentum	1
change in momentum (on reflection) creates a force	1
 <p>(1 mark if angles not approximately correct)</p>	2

Question 23(b)
Compton scattering

Description	Mark
Particle property	1
Possible reasons are momentum is a property of particles, or collisions are characteristic of particles	1

Question 23(c)
Momentum units

Description	Mark
Particle : $p = m v = \text{kg m s}^{-1}$	1
Photon : $p = \frac{h}{\lambda} = \frac{\text{J s}}{\text{m}}$	1
$= \frac{\text{kg m}^2 \text{ s}}{\text{s}^2 \text{ m}} = \text{kg m s}^{-1}$	1

Question 23(d)(i)
Higher momentum

Description	Mark
X-ray photon has the larger momentum	1
Reason : It has a smaller wavelength	1

Question 23(d)(ii)
Momentum calculation

Description	Mark
$E = \frac{hc}{\lambda} \quad \lambda = \frac{hc}{E}$	1
$p = \frac{h}{\lambda} = \frac{hE}{hc} = \frac{E}{c}$	1
$p = \frac{110 \times 10^3 \times 1.6 \times 10^{-19}}{3 \times 10^8} = 5.87 \times 10^{-23} \text{ kg m s}^{-1}$	1

Question 23(d)(iii)
Scattering angle

Description	Mark
Needs to be scattered through 180°	1
$\cos(180^\circ) = -1$ so change in wavelength is greatest	1

Question 23(e)
Energy of scattered electron

Description	Mark
$\lambda' = \lambda + \frac{h}{mc}(1 - \cos \theta) = \frac{hc}{E} + \frac{h}{mc}(1 - \cos \theta)$ $= 1.251 \times 10^{-11} \text{ m}$	1
$E' = \frac{hc}{\lambda'} = 1.59 \times 10^{-14} \text{ J} = 99.2 \text{ keV}$ $= 99.2 \text{ keV}$	1
Hence scattered electron energy is 19.8 keV or $3.17 \times 10^{-15} \text{ J}$	1

Overall - units

Description	Mark
Consistent, appropriate use of units in final answers (no more than two unit errors in entire paper) or	2
Inconsistent or inappropriate use of units in final answers (three or four unit errors in entire paper) or	1
Poor use of units in final answers (five or more unit errors in entire paper)	0

Overall – significant digits

Description	Mark
Consistent, appropriate use of significant digits in final answers (no more than two SD errors in entire paper) or	2
Inconsistent or inappropriate use of significant digits in final answers (three or four SD errors in entire paper) or	1
Poor use of significant digits in final answers (five or more SD errors in entire paper)	0

Physics Stage 3 exam

	3A				3B		
	Working in physics	Motion and forces in a gravitational field	Electricity and magnetism		Working in physics	Particles, waves and quanta	Motion and forces in electric and magnetic fields
SECT 1							
1						Dpt 7	
2		Dpt 9					
3						Dpt 15	
4		Dpt 12					
5		Dpt 10					
6			Dpt 2, 3				
7			Dpt 8				
8						Dpt 1	
9			Dpt 9				
10		Dpt 3, 13					
11							Dpt 4
12		Dpt 2, 3					
13		Dpt 2, 9					
14							Dpt 6
15						Dpt 11	
SECT 2							
16						Dpt 3, 4	
17						Dpt 9, 10, 16	
18			Dpt 8, 9		X		
19						Dpt 6, 10, 16	Dpt 4
20	X	Dpt 1, 2, 5					
21		Dpt 5	Dpt 5				Dpt 3, 4, 6
SECT 3							
22					X		
23		Dpt 5			X	Dpt 5, 6	
overall							
	X				X		

		section 1 items	section 1 marks	section 2 items	section 2 marks	section 3 items	section 3 marks	overall marks*	total marks	total %	total allowed
15– 20%	Working in Physics	nil	0	20c	4	22a, 22b(ii), 22c, 23c, 23d, 23e	19	4	27	19.3	15-20%
20– 25%	Motion and forces in a gravitational field	2, 4, 5, 10, 12, 13	19	20a, 20b, 21a	9	23a, 22b(i)	7		35	25	20-25%
15-20%	Electricity and magnetism	6, 7, 9	10	18a, 18b, 18c, 18d,	13				23	16.4	15-20%
20– 25%	Particles, waves and quanta	1, 3, 8, 15	8	16a, 16b, 17a, 17b, 19a, 19b	24	23b	2		34	24.3	20-25%
15– 20%	Motion and forces in electric and magnetic fields	11, 14	6	19c, 21b, 21c, 21d, 21e,	15	-	-		21	15	15-20%
totals		13 items	43	6 items	65	2 items	28	4	140	100	
total %			30.7		46.4		20	2.9			
total allowed		12-15 items	25-35%	6-8 items	45-55%	1-2 items	15-25%	2-3%			

* 'overall marks' refers to an allocation for appropriate use of units and significant digits.