UNIT 2: FORCES, SPACE and RADIOACTIVITY
HIGHER TIER

MARK SCHEME

GENERAL INSTRUCTIONS

Recording of marks

Examiners must mark in red ink.

One tick must equate to one mark (apart from the questions where a level of response mark scheme is applied).

Question totals should be written in the box at the end of the question.

Question totals should be entered onto the grid on the front cover and these should be added to give the script total for each candidate.

Marking rules

All work should be seen to have been marked.

Marking schemes will indicate when explicit working is deemed to be a necessary part of a correct answer.

Crossed out responses not replaced should be marked.

Credit will be given for correct and relevant alternative responses which are not recorded in the mark scheme.

Extended response question

A level of response mark scheme is used. Before applying the mark scheme please read through the whole answer from start to finish. Firstly, decide which level descriptor matches best with the candidate's response: remember that you should be considering the overall quality of the response. Then decide which mark to award within the level. Award the higher mark in the level if there is a good match with both the content statements and the communication statements.

Marking abbreviations

The following may be used in marking schemes or in the marking of scripts to indicate reasons for the marks awarded.

cao = correct answer only
ecf = error carried forward
bod = benefit of doubt

Question				Marking details	Marks Available					
					AO1	AO2	AO3	Total	Maths	Prac
1	(a)			0.16 [s]		1		1	1	
	(b)			Selection and substitution: $\frac{100}{9.58}$ (1) Speed = 10.44 (1) Unit = m/s (1)	1 1	 1		 3	 2	
	(c)			They need strong leg muscles / big muscle mass relative to body weight (1) which are needed to exert a large force on the ground (1)		2		2		
	(d)			To obtain maximum/greatest <u>forward</u> force on the sprinter (1) To give maximum/large [initial] acceleration (1)			2	2		
	(d)			Continuous line from (0,0) to (60,12.4) (1) Line has decreasing gradient (1) Any line showing small decrease in speed beyond (80,12.4) (1)		1 1	 1	 3	 3	
				Question 1 total	**2**	**6**	**3**	**11**	**6**	**0**

Question				Marking details	Marks Available					
					AO1	AO2	AO3	Total	Maths	Prac
2	(a)			The ball decelerates as it rises until it comes to a stop vertically (1) then it accelerates as it falls (1) because gravity pulls down on it (1)		3		3		
	(b)	(i)		Change in momentum = $0.16 \times (0 - 40)$ (1) $= [-]6.4$ [kg m/s] (1)	1	1		2	2	
		(ii)		Selection and substitution: $\frac{6.4}{0.4}$ (1) **ecf** = 16 [N] (1)	1	1		2	2	
		(iii)		32 [N] **ecf**		1		1	1	
	(c)			Bend knees on landing (1) Increases time to stop (1) which decreases the force on legs (1)			3	3		
				Question 2 total	**2**	**6**	**3**	**11**	**5**	**0**

Question				Marking details	Marks Available					
					AO1	**AO2**	**AO3**	**Total**	**Maths**	**Prac**
3	(a)	(i)		Linear scale marked on W axis (intervals of 1 N) (1) All 6 points correctly plotted within ±½ small square division (1) Smooth curve of best fit within ± ½ small square division of all points (1) Don't accept thick, double, whispy lines		3		3	3	3
		(ii)		As the distance increases, W decreases (1) at a decreasing rate (1). A statement of inversely proportional gets 2 marks. A statement of $W \times d$ is constant or is equal to 30 gets 2 marks.		2		2	2	2
		(iii)		The statement is not entirely true (1) If W were increased by 0.5 N then d would decrease by 6.0 cm but if it were decreased by 0.5 N then d would increase by 10.0 cm (1)			2	2		2
	(b)			Clockwise moment = 200 + 40 = 240 [N cm] **and** Anticlockwise moment = $F \times 40$ [N cm] (1) $F = \frac{240}{40}$ = 6 [N] (1) Hence the student's prediction was incorrect (1) **Alternative solution:** 200 + 40 = $F \times 40$ (1), so $F = \frac{240}{40}$ = 6 [N] (1) Hence the student's prediction was incorrect (1) **Alternative solution:** Using the student's prediction, clockwise moment = 40×5 = 200 N cm (1) Total anticlockwise moment = 240 N cm, ruler not balanced (1) Hence student incorrect.			3	3	2	3
				Question 3 total	**0**	**5**	**5**	**10**	**7**	**10**

Question				Marking details	Marks Available					
					AO1	AO2	AO3	Total	Maths	Prac
4	(a)			3×10^8 [km/year]		1		1	1	
	(b)	(i)		4.5×10^8 [km]		1		1	1	
		(ii)		Substitution: $\frac{2.67 \times 10^9}{5.8 \times 10^8}$ (1) Time = 4.60 [years] (1)	1 1			2	2	
	(c)			Temperature θ in the range - 45 $\leq$ $\theta \leq$ - 100 [^{o}C] (1) Temperature lies somewhere between - 23 and -150 [^{o}C] for Mars and Jupiter (1)	2			2		
	(d)			1. Ceres has a greater distance to travel in one orbit (1) 2. Speed of Ceres is less than that of the Earth / The gravitational attraction of the Sun on Ceres is less than on the Earth (1)	2			2		
				Question 4 total	**5**	**3**	**0**	**8**	**4**	**0**

Question				Marking details	Marks Available					
					AO1	AO2	AO3	Total	Maths	Prac
5				**Indicative content:** The evidence consists of two parts: absorption spectra from distant galaxies and the existence of CMBR. Absorption spectra from distant galaxies which consist of coloured light crossed with black lines. The wavelengths of the black lines are shifted to the red end of the spectrum when compared with light from similar sources in the laboratory. The reason for this is that the galaxies are moving away from us. Those that show the biggest red shift are those that are furthest way. This suggests that the universe began its existence at a single point and has expanded outwards ever since. The time taken in traversing the universe to reach us has resulted in those wavelengths being further red shifted due to the expansion of the universe. CMBR on the other hand initially existed as gamma radiation of very small wavelength but an expanding universe has caused the wavelength to increase into the microwave region of the em spectrum. **5 – 6 marks** Description of red shift, detailed implication of cosmological red shift and of CMBR. *There is a sustained line of reasoning which is coherent, relevant, substantiated and logically structured. The candidate uses appropriate scientific terminology and accurate spelling, punctuation and grammar.* **3 – 4 marks** A description of red shift or cosmological red shift with some aspects of CMBR. *There is a line of reasoning which is partially coherent, largely relevant, supported by some evidence and with some structure. The candidate uses mainly appropriate scientific terminology and some accurate spelling, punctuation and grammar.* **1-2 marks** A simple description of red shift or cosmological red shift or CMBR. *There is a basic line of reasoning which is not coherent, largely irrelevant, supported by limited evidence and with very little structure*. *The candidate uses limited scientific terminology and inaccuracies in spelling, punctuation and grammar.*	6			6		

				0 marks *No attempt made or no response worthy of credit.*							
				Question 5 total	**6**	**0**	**0**	**6**	**0**	**0**

Question				Marking details	Marks Available					
					AO1	AO2	AO3	Total	Maths	Prac
6	(a)			$(2 \times 12.5) + (3 \times 1.8)$ (1) = 30.4 [MN] (1)		2		2	2	
	(b)			Mass of rockets + boosters $= \frac{3 \times 10^7}{10} = 3 \times 10^6$ [kg] (1) Resultant force = $30.4 \times 10^6 - 3 \times 10^7 = 4 \times 10^5$ [N] (1) Acceleration $= \frac{4 \times 10^5}{3 \times 10^6}$ = (1 - sub + manip) = 0.1333 [m/s^2] (1)		4		4	4	
	(c)			$\text{acceleration} = \frac{\text{change in velocity}}{\text{time}}$ $= \frac{7\,500}{360(1)}$ (1 – substitution) = 20.8 [m/s^2] (1)	1	1 1		3	3	
	(d)			Mass reduces (1) Weight reduces so resultant force increases (1) Acceleration is proportional to resultant force [which increases] and inversely proportional to mass [which decreases] so acceleration increases (1)			3	. 3		
				Question 6 total	**1**	**8**	**3**	**12**	**9**	**0**

Question				Marking details	Marks Available					
					AO1	AO2	AO3	Total	Maths	Prac
7	(a)			The isotope with the larger mass number has 8 (or the greater number / more neutrons (1) They both have the same number of protons. (1)	2			2		
	(b)	(i)		Beta particle is a fast moving electron that is emitted from a nucleus	1			1		
		(ii)		131 (1) and -1 (1)	2			2		
	(c)			The beta radiation emitted by iodine-131 (1) would potentially damage / ionise tissue as it passed through the body (1)	2			2		
	(d)	(i)		It / 8 hours is the time taken for the number of nuclei / mass /activity (1) to reduce by half (1)	2			2		
		(ii)		Calculation of 5 half-lives (1) $5 \times 8 = 40$ [days] (1)		2		2	2	
				Question 7 total	**9**	**2**	**0**	**11**	**2**	**0**

Question				Marking details	Marks Available					
					AO1	AO2	AO3	Total	Maths	Prac
8	(a)			The moderator [usually of graphite or water] slows the neutrons (1). This is necessary to increase the probability of them being captured (1) when in collision with nuclei of the uranium fuel (1)	3			3		
	(b)	(i)		Control rods [usually made of boron steel, silver, indium or cadmium] (1) are lowered into the reactor to absorb surplus neutrons (1)	2			2		
		(ii)		Control rods would be fully dropped (1) into the reactor to absorb <u>all</u> neutrons (1)	2			2		
	(c)	(i)		$^{235}_{92}\mathrm{U} + {}^{1}_{0}\mathrm{n} \rightarrow {}^{89}_{36}\mathrm{Kr} + {}^{144}_{56}\mathrm{Ba} + 3{}^{1}_{0}\mathrm{n}$ Symbol equation correct (1) 1 for 3 neutrons on RHS (1)		2		2		
		(ii)		Since $(\frac{1}{2}mv^2)\mathrm{Ba} = (\frac{1}{2}mv^2)\mathrm{n}$ (1) (or by implication) Then $144v^2(\mathrm{Ba}) = 1v^2(\mathrm{n})$ (1) [Hence $v_{\mathrm{Ba}} = \frac{1}{12}v_{\mathrm{n}}$] Accept m_{Ba} = 144 m_{n} for first mark **OR**: accept (for 1 mark) that Ba has a bigger mass, so needs less speed for <u>the same kinetic energy</u> (as the neutron).			2	2	2	
				Question 8 total	**7**	**2**	**2**	**11**	**2**	**0**

HIGHER TIER

SUMMARY OF MARKS ALLOCATED TO ASSESSMENT OBJECTIVES

Question	AO1	AO2	AO3	TOTAL MARK	MATHS	PRAC
1	2	6	3	11	6	0
2	2	6	3	11	5	0
3	0	5	5	10	7	10
4	5	3	0	8	4	0
5	6	0	0	6	0	0
6	1	8	3	12	9	0
7	9	2	0	11	2	0
8	7	2	2	11	2	0
TOTAL	32	32	16	80	35	10