

YEAR 2 | MODULE 5 | PACK 03

Orbital, magnetic and Doppler applications

Official past-paper mark scheme

2017-2023 | OCR A H556 | 5.2 applied with later sections of modules 5 and 6

32 marks | 10 question entries

Later applications - use after the required topics

Match each extract using its question number and stable CM identifier. Original OCR answers, examiner guidance, alternatives, diagrams and level descriptors are preserved.

The heading gives the maximum marks for the assigned subparts. Alternative methods and "any n from" lists offer routes to those marks; do not add every printed point together.

Click a source reference to open OCR's full official mark scheme. Keep this file closed while attempting the questions.

Reserved: all 2024 and 2025 papers are excluded. These files contain official examination questions only; no sample, specimen or practice papers.

Question index

CM identifiers are stable across the question packs and mark schemes; Q numbers refer to this pack. All MCQs appear first.

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CM identifiers are stable across the question packs and mark schemes; Q numbers refer to this pack. All MCQs appear first.

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Q01 | CM04

1 mark

June 2023 | H556/01 | Q11

Question	Answer	Marks	Guidance
11	D	1	

Q02 | CM01

1 mark

June 2017 | H556/02 | Q11

Question	Answer	Marks	Guidance
11	D	1	

Q03 | CM02

1 mark

June 2018 | H556/02 | Q10

Question	Answer	Marks	Guidance
10	C	1	

Q04 | CM03

1 mark

June 2022 | H556/02 | Q7

Question	Answer	Marks	Guidance
7	A	1	

3 marks

Question			Answer	Marks	Guidance
		(iii)	$\frac{GMm}{r^2} = \frac{mv^2}{r} \quad \text{or} \quad v^2 = \frac{GM}{r}$ $(2.14 \times 10^3)^2 = 6.67 \times 10^{-11} \times M / 9380 \times 10^3$ $M = 6.44 \times 10^{23} \text{ (kg)}$	C1 C1 A1	Allow ecf of answer for T from (a)(ii) Allow 2 SF answer Note: Use of 2.8×10^4 seconds gives 6.3×10^{23} (kg) for 3 marks. Alternative Method for C1C1 • $M = 4\pi^2 R^3 / (T^2 G)$ (Databook formula re-arranged with M as subject) • $M = 4\pi^2 (9380 \times 10^3)^3 / ((2.75 \times 10^4)^2 \times 6.67 \times 10^{-11})$ (i.e. M as subject) Note: In alternative method, PoT error forgetting km->m conversion gives 6.46×10^{14} (kg) for 2 marks.

Q06 | CM22

3 marks

June 2022 | H556/01 | Q23(a)

Question			Answer	Marks	Guidance
23	a		$G \frac{Mm}{r^2} = \frac{mv^2}{r}$ or $G \frac{Mm}{r^2} = mr\omega^2$ $v = \frac{2\pi r}{T}$ or $\omega = \frac{2\pi}{T}$ Substitution and manipulation to give $T^2 = \frac{4\pi^2}{GM} r^3$ (with $\frac{4\pi^2}{GM}$ is constant)	M1 M1 A1	Allow any subject

Q07 | CM18

6 marks

November 2021 | H556/01 | Q20(b)

Question	Answer	Marks	Guidance
(b)*	Level 3 (5–6 marks) Clear description and correct calculations leading to value of total energy (must include the negative sign) <i>There is a well-developed line of reasoning which is clear and logically structured. The information presented is relevant and substantiated.</i> Level 2 (3–4 marks) Some description and some correct calculations or Correct calculations (including the negative sign) <i>There is a line of reasoning presented with some structure. The information presented is in the most-part relevant and supported by some evidence.</i> Level 1 (1–2 marks) Limited description or Limited calculations <i>The information is basic and communicated in an unstructured way. The information is supported by limited evidence and the relationship to the evidence may not be clear.</i> 0 marks No response or no response worthy of credit.	B1×6	Indicative scientific points may include: Description - Orbit above the equator / equatorial orbit - Orbit from west to east/same direction of orbit as Earth's rotation - Orbital period is 24 hours / 1 (sidereal) day / 23hrs 56mins (4 s) - Orbit is circular / above the same point on the Earth Calculation $E = (-)\frac{GMm}{r}$ $E = \frac{6.67 \times 10^{-11} \times 5.97 \times 10^{24} \times 2500}{4.22 \times 10^7} = (-) 2.4 \times 10^{10} \text{ J}$ $v = \frac{2\pi r}{T} = \omega r$ $v = \frac{2\pi \times 4.22 \times 10^7}{24 \times 3600} = 3.07 \times 10^3 \text{ m s}^{-1}$ $E = \frac{1}{2}mv^2$ $E = \frac{1}{2} \times 2500 \times [3.07 \times 10^3]^2 = 1.2 \times 10^{10} \text{ J}$ - Total energy = $- 2.4 \times 10^{10} + 1.2 \times 10^{10} = - 1.2 \times 10^{10} \text{ J}$ - Allow full credit for algebraic proof using $\frac{GMm}{r^2} = \frac{mv^2}{r}$, $E = (-)\frac{GMm}{r}$, $E = \frac{1}{2}mv^2$ and total energy = KE + PE Allow higher order answers in terms of Lagrange's Identity

Q08 | CM13

3 marks

June 2019 | H556/02 | Q20(a)

Question			Answer	Marks	Guidance
20	(a)		$F = BQv$ and $F = mv^2/r$ or $B = mv/QR$ (Any subject)	C1	Allow e
			$(B =) \frac{1.4 \times 10^{-25} \times 4.8 \times 10^4}{1.6 \times 10^{-19} \times 0.18}$	C1	
			$B = 0.23 \text{ (T)}$	A1	

Q09 | CM15

3 marks

June 2019 | H556/03 | Q6(c)(i), (c)(iv)

Question			Answer	Marks	Guidance
	(c)	(i)	$T = 0.50 \text{ (s)}$ or $f = 2.0 \text{ (Hz)}$ $v = (2\pi r/T) = 2\pi \times 0.60/0.5$ $v = 7.5 \text{ (m s}^{-1}\text{)}$	C1 M1 A0	Allow $1.2\pi/0.5$ or 2.4π $= 7.54 \text{ (m s}^{-1}\text{)}$ <u>Alternative method:</u> $\omega = 4\pi$ or $12.6 \text{ (rad s}^{-1}\text{)}$ (C1) $v (= r \omega) = 0.60 \times 12.6$ or 2.4π (M1) $= 7.54 \text{ (m s}^{-1}\text{)}$ (A0)

Question			Answer	Marks	Guidance
		(iv)	X labelled at lowest point of circle on Fig. 6.1	B1	

Q10 | CM12

10 marks

June 2018 | H556/03 | Q3

Question			Answer	Marks	Guidance
3	(a)	(i)	(For circular orbit) <u>centripetal</u> force provided by <u>gravitational</u> force (of attraction) (Gravitational / centripetal) force is along line joining stars which must therefore be diameter of circle (AW)	M1 A1	
		(ii)	$T = 20.5 \times 86400 (= 1.77 \times 10^6 \text{ s})$ and $R = 1.8 \times 10^{10} \text{ (m)}$ $m = 16 \times \pi^2 \times (1.8 \times 10^{10})^3 / G \times (20.5 \times 86400)^2$ giving $m = 4.4 \times 10^{30}$ so $m = 2.2 M_{\odot}$	C1 C1 A1	values of T and R scores first mark; both incorrect 0/3 correct substitution allowing π^2 and G $m = 16 \times 9.87 \times 1.8^3 \times 10^{30} / 6.67 \times 10^{-11} \times 1.8^2 \times 10^{12}$ using 2R gives $35.2 \times 10^{30} = 17.6 M_{\odot}$ or using T = 1 day gives $1850 \times 10^{30} = 930 M_{\odot}$ award 2/3
	(a)	(iii)	$v = 2\pi R/T = 2 \times 3.14 \times 1.8 \times 10^{10} / 1.8 \times 10^6$ (giving $v = 6.3$ or 6.4×10^4) $\Delta\lambda = (v/c)\lambda = (6.3/3) \times 10^{-4} \times 656 = 0.14 \text{ (nm)}$	C1 A1	do not penalise repeated error for R or T ecf for incorrect v, gives $\Delta\lambda = v \times 2.2 \times 10^{-6}$ $\Delta\lambda = 0.28$ for 2R; $\Delta\lambda = 2.9$ for 1 day and $\Delta\lambda = 5.7$ for both incorrect
	(b)	(i)	Two circles with centres at CoM with radii in ratio 4 :1 CoM at surface of larger star on line joining stars	B1	allow diameter of m orbit through CoM as $44 \pm 10 \%$ for example; full reasonable circles required; ignore arrows;
	(b)	(ii)	Same period/(angular) frequency of stars but longer path for smaller star/AW or $v = 2\pi R/T$ or $v \propto R$ or stars stay at opposite ends of line through CoM	B1 B1	any arguments using $F = mv^2/r$ score zero