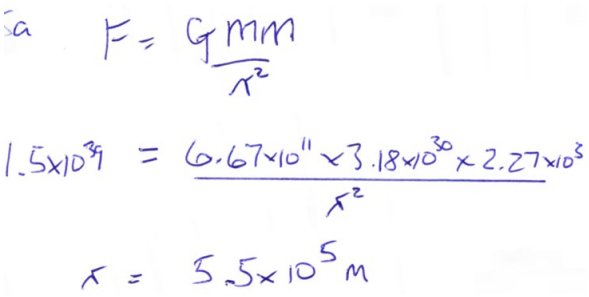
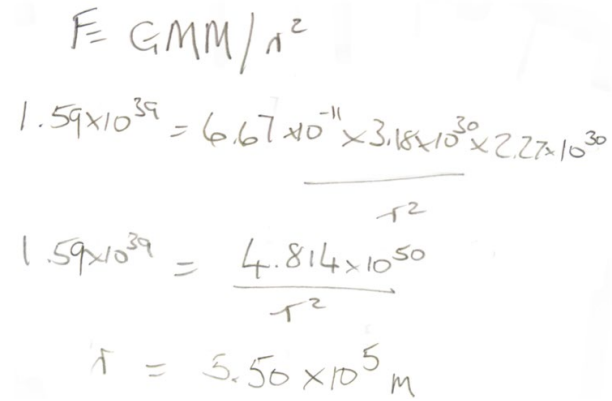
Question			Expected response	Max mark	Additional guidance
5.	(a)		$F = G\frac{m_1 m_2}{r^2}$ **(1)** $1{\cdot}59\times10^{39} = 6{\cdot}67\times10^{-11}\times\frac{3{\cdot}18\times10^{30}\times2{\cdot}27\times10^{30}}{r^2}$ **(1)** $r = 5{\cdot}50\times10^{5}$ m **(1)**	**3**	Accept: 5·5, 5·503, 5·5029
	(b)	(i)	Waves <u>meet</u> 180°/completely/totally/exactly out of phase **OR** Crest <u>meets</u> trough **OR** Path difference = $\left(m+\frac{1}{2}\right)\lambda$	**1**	Can be shown by appropriate diagram
		(ii)	$\left(\frac{4{\cdot}0\times10^{-18}}{4{\cdot}0\times10^{3}} = \right)10^{-21}$ **(1)** (change in length is) <u>21</u> orders of magnitude <u>smaller</u> **(1)**	**2**	Accept $\left(\frac{10^{-18}}{10^{3}} = \right)10^{-21}$ **OR** (-18-3) = -21 **(1)** Accept 21 <u>smaller</u> on its own **(2)** Do not accept 21 <u>times</u> smaller on its own (0) Accept $\left(\frac{10^{3}}{10^{-18}} = \right)10^{21}$ **OR** 3-(-18) = 21 **(1)** Accept: the length of the arm is 21 orders of magnitude greater than the change in length. **(1)**

Q5(a) **Maximum mark: 3**

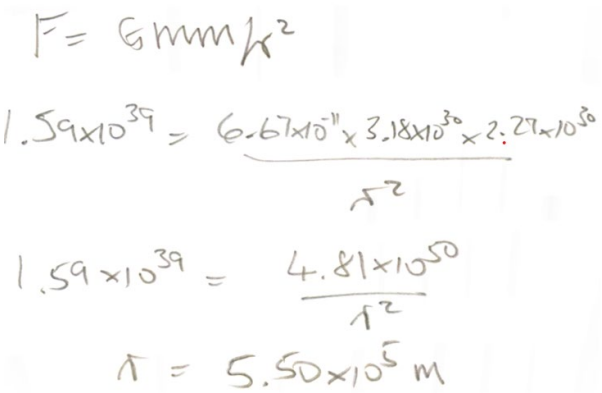
Response A **Marks**



Response B



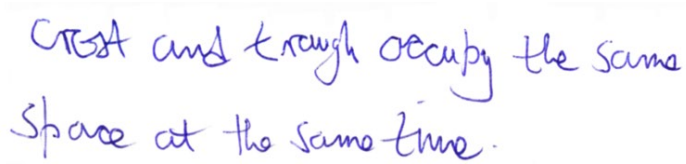
Response C



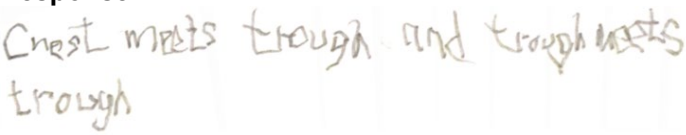
Q5(b)(i) **Maximum mark: 1**

Response A

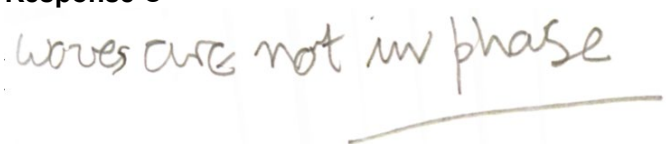
Marks



Response B



Response C



5(a)	A	3	1	The candidate has selected an appropriate relationship but has not correctly substituted values ($G = 6.67 \times 10^{11}$ rather than $G = 6.67 \times 10^{-11}$). Following an incorrect substitution, a correct substitution cannot be implied by an acceptable final answer.
	B	3	2	The candidate has selected an appropriate relationship and correctly substituted values. They have, however, incorrectly rounded the calculated value on the nominator of the vulgar fraction at an intermediate stage (4.814 is incorrectly rounded from 4.8148 …). Despite a correct final answer, this is treated as an arithmetic error and the mark for the final answer is not awarded.
	C	3	3	The candidate has selected an appropriate relationship and correctly substituted values. They have rounded the value on the nominator of the vulgar fraction at an intermediate stage (4.81) but have given the correct final answer. Rounding at an intermediate stage is not good practice but is only penalised if the rounding is incorrect or if correct intermediate rounding results in an unacceptable final answer.
5(b)(i)	A	1	1	The candidate has given an acceptable alternative explanation.
	B	1	0	The candidate's explanation is incorrect.

Question	Candidate response	Max mark	Mark awarded	Commentary
	C	1	0	The candidate's explanation is not sufficiently precise.