Question Number	Answer	Mark
1 (a)	**Either**: $F = GMm/r^2$ (or equivalent form of equation) **(1)** With all symbols (except G) defined **(1)** **Or:** Force is directly proportional to the product of the masses. And inversely proportional to the square of their distance apart.	**(2)**
(b) (i)	Correct attempted use of above equation with given masses and distances (ignore powers of 10) **(1)** Correct answer 0.59 (N) **(1)** Example of answer: $F = \frac{GMm}{r^2}$ $= \frac{6.67\times10^{-11}\ \text{N m}^2\ \text{kg}^{-2} \times 1.0\times10^{10}\ \text{kg} \times 2.0\times10^{4}\ \text{kg}}{(150\ \text{m})^2}$ $= 0.59(3)\ \text{N}$	**(2)**
(ii)	$F = ma \rightarrow a = F/m$ [Correct use of equation, with 'm' being the mass of the asteroid, and F the force value from part (i).] **(1)** [OR use of 'g' = GM/r^2, *with* 'M' being the mass of the tractor.] Correct answer 5.9 x 10^{-11} m s^{-2} [or 6.0 x 10^{-11} m s^{-2}] **(1)** Example of answer: $a = \frac{F}{m} = \frac{0593\ \text{N}}{1.0\times10^{10}\ \text{kg}} = 5.9\times10^{-11}\ \text{m s}^{-2}$	**(2)**
	(iii) 2.0 × 10^4 kg / the same / unchanged. **(1)** [Allow bald statement or calculation that demonstrates this, ecf their first acceleration value.]	**(1)**
	Total	**7**

Question Number	Answer	Mark
2 (a)(i)	V m^{-1} and N C^{-1}. Substitution of J C^{-1} for V **or** Nm C^{-1} for V **or** kg m s^{-2} for N **(1)** [Answers must be in terms of unit equivalences, not quantities] Completion of valid substitution and manipulation to demonstrate equivalence. **(1)** Example of answer: V m^{-1} = J C^{-1} m^{-1} = N m C^{-1} m^{-1} = N C^{-1}	**(2)**
(ii)	Vertical line drawn mid-way between plates, <u>labelled</u> 3V **(1)** Vertical line drawn just left of three-quarter distance, <u>labelled</u> 4V **(1)** [Gauge by eye, ignore 'edge effects' at plate edges]	**(2)**
(b) (i)	E = V/d and $F = Eq$. **(1)** [Correct statement of <u>both</u> equations, or re-arrangements, or combination] E = 1.5 (V cm^{-1}) or 150 (V m^{-1}) (no u.e.) **(1)** [Correct use of first equation to get numerical field value] Correct answer 2.4×10^{-17} N **(1)** [Correct use of second equation to get force value (ecf their E)] [Correct final answer gets 3/3] Example of answer: $F = \frac{V \times q}{d} = \frac{6.0\ \text{V} \times 1.6 \times 10^{-19}\ \text{C}}{4.0 \times 10^{-2}\ \text{m}} = 2.4 \times 10^{-17}\ \text{N}$	**(3)**
(ii)	Correct answer 5.0 x 10^{10} (s^{-1}) **(1)** [Correct numerical value] Example of answer: $n = \frac{8.0 \times 10^{-9}\ \text{C s}^{-1}}{1.6 \times 10^{-19}\ \text{C}} = 5.0 \times 10^{10}\ \text{s}^{-1}$	**(1)**
	Total	**8**

Question Number	Answer	Mark
3(a) (i)	Correct answer 31 (J) (or 31.25 / 31.3 / 31.2) (J). **(1)** [Correct use of $E = ½CV^2$ equation to find E to 2s.f. or better] Example of answer: $E = \frac{CV^2}{2} = \frac{10\,\text{F} \times (2.5\,\text{V})^2}{2} = 31.3\,\text{J}$	**(1)**
(ii)	(ii) Use of volume = $\pi r^2 h$, with r = 0.5 and h = 2 **(1)** [i.e. ignore powers of 10] Correct answer 2.0 / 1.9 $\times 10^7$ (J m^{-3}) **(1)** [31.3J → 2. 0 × 10^7 , 30J → 1.9 x 10^7] Example of answer: $\frac{E}{V} = \frac{31.3\ \text{J}}{\pi \times (0.5 \times 10^{-2}\ \text{m})^2 \times 2.0 \times 10^{-2}\ \text{m}} = 2.0 \times 10^7\,(\text{J m}^{-3})$	**(2)**
(b) (i)	Use of $Q = CV$ and $Q = It$ **or** of R = V/I and t = RC Q = 25 (C) (no u.e.) **or** R = 12.5 (Ω) (no u.e.) **(1)** [Correct use of first equation to get charge or resistance value] Correct answer 125 s **(1)** [Correct use of second equation to get time value (ecf errors in their Q or R)] [Correct final answer gets both marks] Example of answer: $Q = CV = 10\ \text{F} \times 2.5\ \text{V} = 25\ \text{C}$ $t = \frac{Q}{I} = \frac{25\ \text{C}}{0.2\ \text{A}} = 125\ \text{s}$	**(2)**
	(ii) Why current not constant? The potential difference/voltage will fall. **(1)**	**(1)**
	Total	**6**

Question Number	Answer	Mark
4(a)	(i) Parallel, equally-spaced lines (minimum 3) between P and Q and perpendicular to them. **(1)** [ignore edge effects] with arrows on at least 2 of the lines to show direction towards Q. **(1)**	**(2)**
	(ii) Field <u>is</u> uniform (along the line / between the centres of the magnets) **(1)** but <u>may</u> not be nearer the edges / away from the central line. **OR** but the experiment does not give information about the field nearer the edges / away from the central line. } **(1)**	**(2)**
(b) (i)	Field pattern shows following features: Vertical 'cross' shape (no field lines drawn meeting or crossing, minimum 2 lines from each magnet) **(1)** Arrows on field lines so directions are downwards on lines from P and upwards on lines from Q [ecf direction in a(i)] **(1)** 'Neutral point' clearly labelled approximately centrally between P and Q **(1)**	**(3)**
(ii)	Line (straight or curved) begins at positive value in range 2 to 4 units for distance = 0cm **and** ends at equal negative reading -2 to -4 units at distance = 3cm. } **(1)** [Line is straight or shows reasonable rotational symmetry] Reading is 0 at distance = 1.5cm but not elsewhere. **(1)**	**(2)**
	Total	**9**

Question Number	Answer	Mark
5(a)	(a) Fleming's Left hand rule / (Fleming's / The) motor rule **(1)** (b) Arrow, labelled *F*, acting on wire S, to right. **(1)** **[accept on figure 1]** (c) Arrow upwards on wire R **(1)** (d) Arrow, labelled *B*, acting up the page. **(1)** Arrow length is (approximately) **4 x** $\lvert B_{R/S} \rvert$, (acting up the page). **(1)**	**(5)**
	Total	**5**

Question Number	Answer	Mark
6(a)	QoWC **(1)** And/or one mark each for any of: The input voltage (or current) is alternating / a.c. **(1)** → alternating/changing (magnetic) field/flux [not 'flux linkage' here] in primary/core. **(1)** → alternating/changing (magnetic) field/flux/flux linkage in secondary. **(1)** → Induced e.m.f. (in secondary) ['in secondary' stated or implicit] **or** emf (in secondary) according to Faraday's law of electromagnetic induction **(1)** $V_2 < V_1$ **because** $N_2 < N_1$; [link to turns values must be explicit]. **(1)**	**(Max 5)**
	Total	**5**
	Total for paper	**40**