Question			Answers	Notes	Total
2	a		Read at least two points correctly and consistently ✓ Use $\frac{1}{2} \cdot g \cdot t^2$ with a length interval from two non-consecutive points OR for two (or more) length intervals, using consistent time intervals ✓ Correct calculation of g ✓	*Award [2] max if they use one single length interval of consecutive points.* *Award [1] max if they miss to subtract the initial point in their length interval or if they use inconsistent time intervals.* *Do not penalize significant figures in the final answer.*	3

	b		Use 10% for delta t^2 ✓ Estimate an uncertainty for s using an absolute of 0.5 OR 1 mm AND propagate it to 1/their length interval OR 2/their length interval respectively ✓ Add both relative or percentage uncertainties AND calculate the absolute uncertainty ✓	*Allow ECF for MP3.* *Do not penalize significant figures in the final answer.*	**3**
	c		Flash must be so short that blurring is within the absolute uncertainty / error of determination of *s* ✓ (Final) speed is around 2 m s^{-1} and error is about 1 mm so (maximum) duration around $\frac{1}{2000}$ *s* ✓	*Award [1] max if they argue that images might merge and state a maximum of 0.025 s (or less).* *Award [1] max if they use the uncertainty of time and state a time of (2 x) 0.05 x 0.05 s = 0.005 s (or less).* *Award MP2 if they state an interval of 0.001 s or less.*	**2**

Question			Answers	Notes	Total
7.	a	i	equally spaced arrows «by eye» all pointing down ✓ edge effects also shown with arrows ✓		2
7.	a	ii	$E = \frac{V}{d} = \frac{960}{8.0 \times 10^{-3}}$ ✓ $E = 1.2 \times 10^{5}$ «NC^{-1}» ✓		2
7.	b		friction transfers electron(s) to or from drop ***AND*** through collisions/ interaction with air molecules in the tube OR through collisions/interaction with wall of tube ✓		1
7.	c	i	weight of oil drop is $\rho_o gV$ ✓ $\frac{F_b}{W} = \frac{\rho_a gV}{\rho_o gV} = \frac{\rho_a}{\rho_o}$ ✓ «$\frac{F_b}{W} = \frac{1}{730}$ =»1.4×10^{-3} ***OR*** Ratio of F_b to W is much less than 1 ✓		3

7.	**c**	**ii**	Weight vertically down ***AND*** electric force vertically up ✓ Of equal length «by eye» ✓		**2**
7.	**c**	**iii**	Mass of drop is $\rho_0 V$ ✓ $qE = (\rho_0 V)g$ ✓ «hence answer»	*MP1 must be shown implicitly for credit.*	**2**
7.	**c**	**iv**	Negative ✓		**1**
7.	**d**	**i**	Net force is zero ✓ Acceleration of the oil drop is zero ✓ ***OR*** For terminal velocity drag must equal weight ✓ weight $= \rho_0 gV$ **and** drag $= 6\pi\eta rv$ ✓		**2**

7.	**d**	**ii**	$q = \frac{6\pi\eta r v}{E}$ ✓ $q = \frac{6\pi \times 1.60 \times 10^{-5} \times 1.36 \times 10^{-6} \times 1.40 \times 10^{-4}}{1.2 \times 10^{5}}$ ✓ $q = 4.79 \times 10^{-19}$ «C» ✓	*Answer must be shown to 3+ sf.*	**3**
7.	**d**	**iii**	charge is quantized ✓ so, the charges must be 1e and 2e ✓		**2**