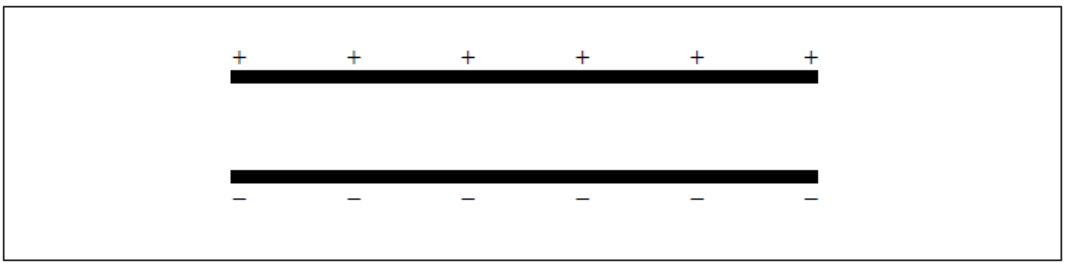
Paper 2 Summary Qs - Fields [29 marks]

1. [Maximum mark: 20]

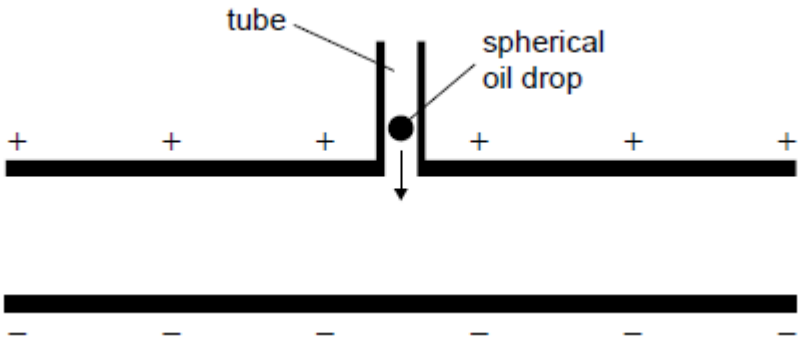
The diagram shows two parallel conducting plates that are oppositely charged.



(a.i) Draw the electric field lines due to the charged plates. [2]

(a.ii) The potential difference between the plates is 960 V and the distance between them is 8.0 mm. Calculate the electric field strength *E* between the plates. [2]

In an experiment, an oil drop is introduced into the space between the plates through a small hole in the upper plate. The oil drop moves through air in a tube before falling between the plates.



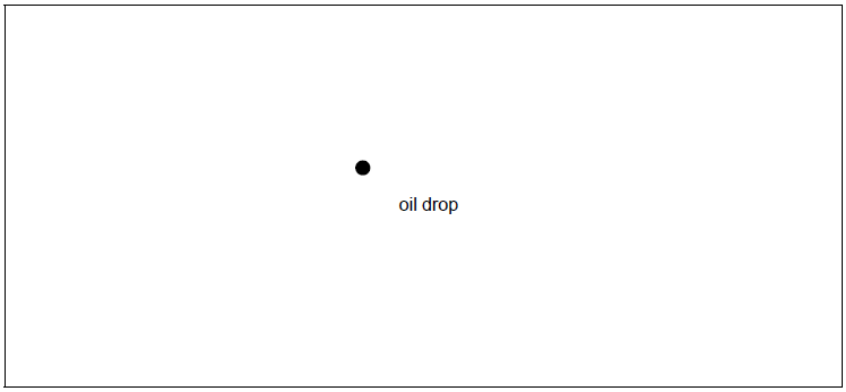
(b) Explain why the oil drop becomes charged as it falls through the tube. [1]

(c) The oil drop is observed to be stationary in the space between the plates. Buoyancy is one of the forces acting on the drop.

The density of oil is 730 times greater than that of air.

(c.i) Show that the buoyancy force is much smaller than the weight. [3]

(c.ii) Draw the forces acting on the oil drop, ignoring the buoyancy force.



[2]

(c.iii) Show that the electric charge on the oil drop is given by

$$q = \frac{\rho_o g V}{E}$$

where ρ_o is the density of oil and V is the volume of the oil drop. [2]

(c.iv) State the sign of the charge on the oil drop. [1]

(d) The electric field is turned off. The oil drop falls vertically reaching a constant speed *v*.

(d.i) Outline why, for this drop, $\rho_o g V = 6\pi\eta r v$ where η is the viscosity of air and r is the radius of the oil drop. [2]

(d.ii) Show that the charge on the oil drop is about $4.8 \times 10^{-19}\,\mathrm{C}$.

The following data for the oil drop are available:

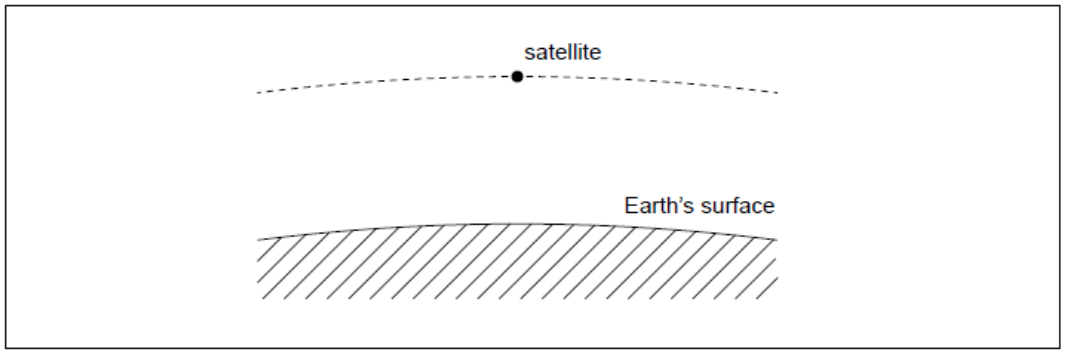
$$r = 1.36\,\mu\mathrm{m}$$
$$\eta = 1.60 \times 10^{-5}\,\mathrm{Pa\,s}$$
$$v = 0.140\,\mathrm{mm\,s^{-1}}$$

[3]

(d.iii) The oil drop splits into two parts of equal mass. Both are charged. Deduce the net charge on each part. [2]

2. [Maximum mark: 4]

A satellite moves around Earth in a circular orbit.



(a) Draw an arrow on the diagram to represent the direction of the acceleration of the satellite. [1]

(b) The following data are given:

Mass of Earth, $M = 5.97 \times 10^{24}$ kg
Radius of Earth, $R = 6.37 \times 10^{6}$ m
Orbital period of the satellite, $T = 5.62 \times 10^{3}$ s

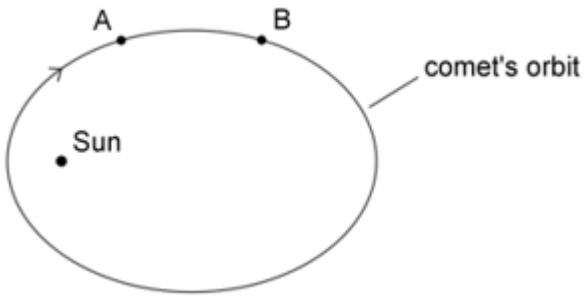
(b.i) Kepler's Third Law of orbital motion states that $T^2 = kr^3$ where k is a constant and r is the orbital radius of the satellite.

Show that $k = \frac{4\pi^2}{GM}$. [1]

(b.ii) Determine the height of the satellite above the Earth's surface. [2]

3. [Maximum mark: 5]

(a) A comet orbits the Sun in an elliptical orbit. A and B are two positions of the comet.



Explain, with reference to Kepler's second law of planetary motion, the change in the kinetic energy of the comet as it moves from A to B. [3]

(b) An asteroid (minor planet) orbits the Sun in a circular orbit of radius 4.5×10^8 km. The radius of Earth's orbit is 1.5×10^8 km. Calculate, in years, the orbital period of the asteroid. [2]