1.

a) $E = \frac{\Delta V}{d} = \frac{100}{1.22} = 82.0 \text{ NC}^{-1}$ (3 s.f.)

b) $W = q\Delta V = 1.1 \times 100 = 110\text{J}$ (2 s.f.)

c) $110 \div 1.6 \times 10^{-19} = 6.9 \times 10^{20}\text{eV}$ (2 s.f.)

d) $F = Eq$ and $W = Fd$ $\therefore W = Eqd$

$W = q\Delta V$

$\therefore q\Delta V = Eqd$

$\therefore \Delta V = Ed$

$\therefore E = \frac{\Delta V}{d}$

2. Both exhibit motion described by a parabola (due to the constant acceleration on one component and zero acceleration on the other). The difference is that for one the acceleration is caused by being a charge in a uniform electric field, while the other is caused by being a mass in a uniform gravitational field.

3. (a) Let y be perpendicular and x be parallel to the plates.

$s_x = v_x t$

$\therefore t = \frac{s_x}{v_x} = \frac{0.100}{1.0 \times 10^7} = 1.0 \times 10^{-8}\text{s}$

(b) $E = \frac{\Delta V}{d} = \frac{150}{0.05} = 3000\text{NC}^{-1}$

$a_y = \frac{F}{m} = \frac{Eq}{m} = \frac{1.6 \times 10^{-19} \times 3000}{9.11 \times 10^{-31}} = 5.3 \times 10^{14} \text{ ms}^{-2}$

(c) $s_y = v_{0y}t + \frac{1}{2}a_y t^2$

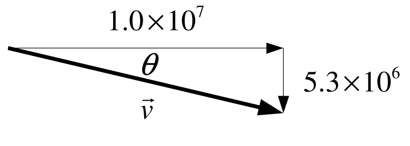
$= \frac{1}{2} \times 5.3 \times 10^{14} \times \left(1.0 \times 10^{-8}\right)^2$

$= 0.026 \text{ m}$ towards the positive plate.

(d) $v_y = v_{0y} + a_y t$

$= 5.3 \times 10^{14} \times 1.0 \times 10^{-8}$

$= 5.3 \times 10^6 \text{ ms}^{-1}$



$v = \sqrt{\left(5.3 \times 10^6\right)^2 + \left(1.0 \times 10^7\right)^2}$

$= 1.1 \times 10^7 \text{ ms}^{-1}$ (2 s.f.)

$\theta = \tan^{-1}\left(\frac{5.3 \times 10^6}{1.0 \times 10^7}\right) = 28°$ (2 s.f.)

The final velocity is $1.1 \times 10^7 \text{ ms}^{-1}$ 28° from the original direction of motion, towards the positive plate.

4.

a) $a = \frac{qE}{m} \qquad \therefore E = \frac{am}{q} = \frac{gm}{q}$ {since a is acceleration due to gravity, g}

$$E = \frac{\Delta V}{d}$$

$$\therefore \frac{\Delta V}{d} = \frac{gm}{q}$$

$$\therefore \Delta V = \frac{gmd}{q}$$

b) $\Delta V = \frac{gmd}{q}$

$$= \frac{9.8 \times 9.11 \times 10^{-31} \times 9.5 \times 10^{-2}}{1.6 \times 10^{-19}}$$

$= 5.3 \times 10^{-12}$ V (2 s.f.)

c) The top is positive.

5.

a) The dees are almost closed hollow conductors and hence have no electric field inside of them.

b) See notes

c) Between the dees there is an electric field. When the ion moves through the field it experiences a force due to its charge (F = Eq) which accelerates it.
The voltage alternates at the same rate as the ion orbits, so the field is always in the right direction to accelerate the ion each time it crosses between the dees.

d) $W = q\Delta V$

$= 1.6 \times 10^{-19} \times 1000$

$= 1.6 \times 10^{-16}$ J per crossing

10 MHz so $2 \times 10 \times 10^{6}$ crossings per second

$\therefore 20 \times 10^{6} \times 4.0 \times 10^{-6}$ crossings total

$= 80$ crossings total

$\therefore$ Total energy $80 \times 1.6 \times 10^{-16}$

$= 1.3 \times 10^{-14}$ J (2 s.f.)

= 80000 eV (2 s.f.)