1. Force per unit positive charge

2. (a) (i) flux = B × A (normal to B) with symbols explained
(ii) linkage = N × flux
A = x^2 so linkage = NBx^2

(b) (i) Statement of Faraday’s law or indication
e.g. V = d(NBx^2) / dt from (a)(ii)
V = NB x^2 dx/dt or V = NBxv / argue area swept out per second as xv
V = 1250 × 0.032 × 0.02 × 0.1
= 0.08 or 80 mV

(ii) equal positive and negative regions
equal positive and negative values of ‘maxima’ labelled on y-axis
value changes within correct time zones, t = 0.2 to 0.4, 0.6 to 0.8 s
‘square pulse’ shape
sinusoidal graphs score zero marks

3. magnetic flux = BA
meanings of B and A, i.e. flux density or field strength and area \( \perp \) to it
magnetic flux linkage refers to the flux linking/passing through a coil;
and equals N × flux where N is the number of turns (of the coil)
Faraday’s law: induced e.m.f./voltage is proportional to rate of change of flux
linkage through it /correct mathematical formulation/AW
Lenz’s law: the direction of the induced e.m.f./voltage is such as to
oppose the motion/change that produced it
relationship of Lenz’s law to conservation of energy or other valid
explanation/discussion/description
max 5 marks
quality of written communication

4. (a) B = F/I with symbols explained or appropriate statement in words; (1)
explicit reference to I and B at right angles/define from F = BQv etc (1)

(b) (i) arrow towards centre of circle
(ii) field out of paper; Fleming’s L.H. rule/moving protons act as
conventional current
(iii) \( F = Bev \) allow \( BQv \)

(iv) \( F = \frac{mv^2}{r}; Bev = \frac{mv^2}{r}; \) (2)
\[
B = \frac{mv}{er} = 1.67 \times 10^{-27} \times 1.5 \times 10^7 / (1.6 \times 10^{-19} \times 60); = 0.0026; T
\]
allow \( Wb \) \( m^{-2} \)

(v) the field must be doubled; (1)
\[
B \propto v \text{ (as m, e and r are fixed) / an increased force is required to maintain the same radius (1)}
\]

5. (a) appropriate shape; lines perpendicular to and touching plate and sphere; (2) arrows towards negative sphere (1)

(b) (i) By moments, e.g \( F \cos 20 = W \sin 20 \) / by triangle of forces / by resolution of forces / other suitable method; \( i.e. \) justification needed (1)
\[
F = 1.0 \times 10^{-5} \tan 20; = 1.0 \times 10^{-5} \times 0.364; (= 3.64 \times 10^{-6} \text{ N}) (2)
\]
triangle of forces gives \( W/F = \tan 70, \text{ etc (1)} \)

(ii) \( E = \frac{F}{Q}; = 3.64 \times 10^{-6} / 1.2 \times 10^{-9} = 3.0 \times 10^3; \text{ N C}^{-1} / \text{ V m}^{-1} \)

(c) \( E = \frac{1}{4\pi\varepsilon_0}Q/r^2; 3.0 \times 10^3 = 9 \times 10^9 \times 1.2 \times 10^{-9}/r^2; \) (2) or use \( F = \frac{1}{4\pi\varepsilon_0}Q^2/r^2; r^2 = 3.6 \times 10^{-3} \) giving \( r = 6 \times 10^{-2} \text{ (m)} (1) \)

(d) field line sketch minimum of 5 lines symmetrical about line joining centres with arrows; (1)
Fig 1 sketch matches RHS of Fig 2/plate analogous to mirror/AW relating to symmetry (1)

6. (i) \( I = \frac{V}{R} = 12/50 \) (1)
\[
= 0.24 \text{ A (1)}
\]

(ii) Power in primary = power in secondary / \( I_p V_p = I_s V_s \) (1)
\[
I_p = 0.24 \times 12 / 230 = 0.0125 \text{ A (1)}
\]
7. (a) (i) \( F \) is towards ‘open’ end of tube; using Fleming’s L.H. rule
(ii) \( F = BIw \)
(iii) \( F = 0.15 \times 800 \times 0.0025; = 3.0 \) (N)

(b) (i) A voltage is induced across moving metal as it cuts lines of flux; (1)
    voltage is proportional to flux change per second; (1)
    the flux change per second is \( Bwv \) / is proportional to the area of
    metal moving through the field per second / is proportional to \( v \) (1)
    or Faraday’s law fully stated; with reasonable attempt to; (2)
    relate flux linkage per second proportionally to speed (1) 

(ii) flux (linkage) doubles; so using Faraday’s law \( V \) doubles; (1)

[10]