

1. Force per unit positive charge B1 [1]
2. (a) (i) flux = $B \times A$ (normal to B) with symbols explained B1
- (ii) linkage = $N \times \text{flux}$ B1
 $A = x^2$ so linkage = NBx^2 B1
- (b) (i) Statement of Faraday's law or indication B1
 e.g. $V = d(NBx^2) / dt$ from (a)(ii) B1
 $V = NB x^2 dx/dt$ or $V = NBxv$ / argue area swept out per second as xv B1
 $V = 1250 \times 0.032 \times 0.02 \times 0.1$ B1
 $= 0.08$ or 80 mV B1
 A0
- (ii) equal positive and negative regions B1
 equal positive and negative values of 'maxima' labelled on y-axis B1
 value changes within correct time zones, $t = 0.2$ to 0.4 , 0.6 to 0.8 s B1
 'square pulse' shape B1
sinusoidal graphs score zero marks
3. magnetic flux = BA 1
 meanings of B and A, i.e. flux density or field strength and area \perp to it 1
 magnetic flux linkage refers to the flux linking/passing through a coil; 1
 and equals $N \times \text{flux}$ where N is the number of turns (of the coil) 1
 Faraday's law: induced e.m.f./voltage is proportional to rate of change of flux linkage through it /correct mathematical formulation/AW 1
 Lenz's law: the direction of the induced e.m.f./voltage is such as to oppose the motion/change that produced it 1
 relationship of Lenz's law to conservation of energy or other valid explanation/discussion/description 2
max 5 marks
 quality of written communication 2
4. (a) $B = F/Il$ with symbols explained or appropriate statement in words; (1) 2
 explicit reference to I and B at right angles/define from $F = BQv$ etc (1)
- (b) (i) arrow towards centre of circle 1
 (ii) field out of paper; Fleming's L.H. rule/moving protons act as conventional current 2
- [10]
- [7]

- (iii) $F = Bev$ allow BQv 1
- (iv) $F = mv^2/r$; $Bev = mv^2/r$; (2)
 $B = mv/er = 1.67 \times 10^{-27} \times 1.5 \times 10^7 / (1.6 \times 10^{-19} \times 60)$; = 0.0026; T (3) 5
 allow $Wb m^{-2}$
- (v) the field must be doubled; (1)
 $B \propto v$ (as m , e and r are fixed)/an increased force is required
 to maintain the same radius (1) 2
- [13]**
5. (a) appropriate shape; lines perpendicular to and touching plate and sphere; (2)
 arrows towards negative sphere (1) 3
- (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)
 $F = 1.0 \times 10^{-5} \tan 20$; = $1.0 \times 10^{-5} \times 0.364$; (= 3.64×10^{-6} N) (2) 3
 triangle of forces gives $W/F = \tan 70$, etc (1)
- (ii) $E = F/Q$; = $3.64 \times 10^{-6} / 1.2 \times 10^{-9} = 3.0 \times 10^3$; $N C^{-1} / V m^{-1}$ 3
- (c) $E = (1/4\pi\epsilon_0)Q/r^2$; $3.0 \times 10^3 = 9 \times 10^9 \times 1.2 \times 10^{-9}/r^2$; (2)
 or use $F = (1/4\pi\epsilon_0)Q^2/r^2$; $r^2 = 3.6 \times 10^{-3}$ giving $r = 6 \times 10^{-2}$ (m) (1) 3
- (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) 2
- [14]**
6. (i) $I = V/R = 12/50$ (1)
 = 0.24 A (1) 2
- (ii) Power in primary = power in secondary / $I_p V_p = I_s V_s$ (1)
 $I_p = 0.24 \times 12 / 230 = 0.0125$ A (1) 2
- [4]**

7. (a) (i) F is towards 'open' end of tube; using Fleming's L.H. rule 2
(ii) $F = BIw$ 1
(iii) $F = 0.15 \times 800 \times 0.0025; = 3.0 \text{ (N)}$ 2
- (b) (i) A voltage is induced across moving metal as it cuts lines of flux/AW; (1)
voltage is proportional to flux change per second/AW; (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) 3
- (ii) flux (linkage) doubles; so using Faraday's law V doubles/AW 2

[10]