

- M1.(a) (i) meter deflects then returns to zero ✓
 current produces (magnetic) field / flux ✓
 change in field / flux through Q induces emf ✓
 induced emf causes current in Q (and meter) ✓
Deflection to right (condone left) then zero is equivalent to 1st mark.
Accept momentary deflection for 1st point.
"Change in field / flux induces current in Q" is just ✓ from the last two marking points.

max 3

- (ii) meter deflects in opposite direction (or to left, or ecf) ✓
 field / flux through P is reduced ✓
 induces emf / current in opposite direction ✓
Ignore references to magnitude of deflection.

max 2

- (b) (i) flux linkage ($= n\Phi = nBA$) = $40 \times 0.42 \times 3.6 \times 10^{-3}$
 $= 6.0(5) \times 10^{-2}$ ✓
Unit mark is independent.
Allow 6×10^{-2} .

Wb turns ✓

Accept 60 mWb turns if this unit is made clear.

Unit: allow Wb.

2

- (ii) change in flux linkage = $\Delta(n\Phi) = 6.05 \times 10^{-2}$ (Wb turns) ✓
 induced emf $\left(= \frac{\Delta(n\Phi)}{\Delta t} \right) = \frac{6.05 \times 10^{-2}}{0.50} = 0.12(1)$ (V) ✓

Essential to appreciate that 6.05×10^{-2} is change in flux linkage for 1st mark. Otherwise mark to max 1.

2

[9]

M2.A

[1]

M3.(a) (i) 60 (degrees) ✓

1

(ii) angle required is 150° ✓

which is $5\pi/6$ [or 2.6(2)] (radians) ✓

Correct answer in radians scores both marks.

2

(b) (i) (magnitude of the induced) emf ✓

Accept "induced voltage" or "rate of change of flux linkage", but not "voltage" alone.

1

(ii) frequency $\left(= \frac{1}{T} \right) = \frac{1}{40 \times 10^{-3}}$ ✓ (= 25 Hz)

no of revolutions per minute = $25 \times 60 = 1500$ ✓

1500 scores both marks.

Award 1 mark for $40s \rightarrow 1.5 \text{ rev min}^{-1}$.

2

(iii) maximum flux linkage ($=BAN$) = 0.55 (Wb turns) ✓

angular speed $\omega \left(= \frac{2\pi}{T} \right) = \frac{2\pi}{40 \times 10^{-3}}$ ✓ (= 157 rad s^{-1})

peak emf ($= BAN\omega$) = $0.55 \times 157 = 86(.4)$ (V) ✓

M4.D

5	a		(magnetic) <u>field</u> is applied perpendicular to path or direction or velocity of charged particles ✓ (magnetic) <u>force</u> acts perpendicular to path or direction or velocity of charged particles ✓ force depends on speed of particle or on B [or $F \propto v$ or $F = BQv$ explained] ✓ force provides (centripetal) acceleration towards centre of circle [or (magnetic) force is a centripetal force] ✓ $BQv = \frac{mv^2}{r}$ or $r = \frac{mv}{BQ}$ shows that r is constant when B and v are constant ✓	max 4
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5	b	i	radius r of path = $\frac{\text{circumference}}{2\pi} = \frac{27 \times 10^3}{2\pi} = 4.30 \times 10^3 \text{ (m)}$ (allow 4.3 km) ✓	3
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			centripetal force $\left(= \frac{mv^2}{r} \right) = \frac{1.67 \times 10^{-27} \times (3.00 \times 10^7)^2}{4.30 \times 10^3}$ ✓ = $3.50 \times 10^{-16} \text{ (N)}$ ✓	
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5	b	ii	magnetic flux density $B \left(= \frac{F}{Qv} \right) = \frac{3.50 \times 10^{-16}}{1.60 \times 10^{-19} \times 3.00 \times 10^7}$ ✓ = 7.29×10^{-5} ✓ T ✓	3
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5	c		magnetic field must be increased ✓ to increase (centripetal) force or in order to keep r constant ✓ [or otherwise protons would attempt to travel in a path of larger radius] [or, referring to , B must increase when v increases to keep r constant]	2
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M6.B

M7.B

M8.B

M9.D

M10.D

M11.A