5 **(a)** A rectangular frame ABCD is supported on two knife-edges P and Q so that the section PBCQ of the frame lies within a solenoid. The solenoid has a current flowing in the direction as shown in Fig. 5.1.

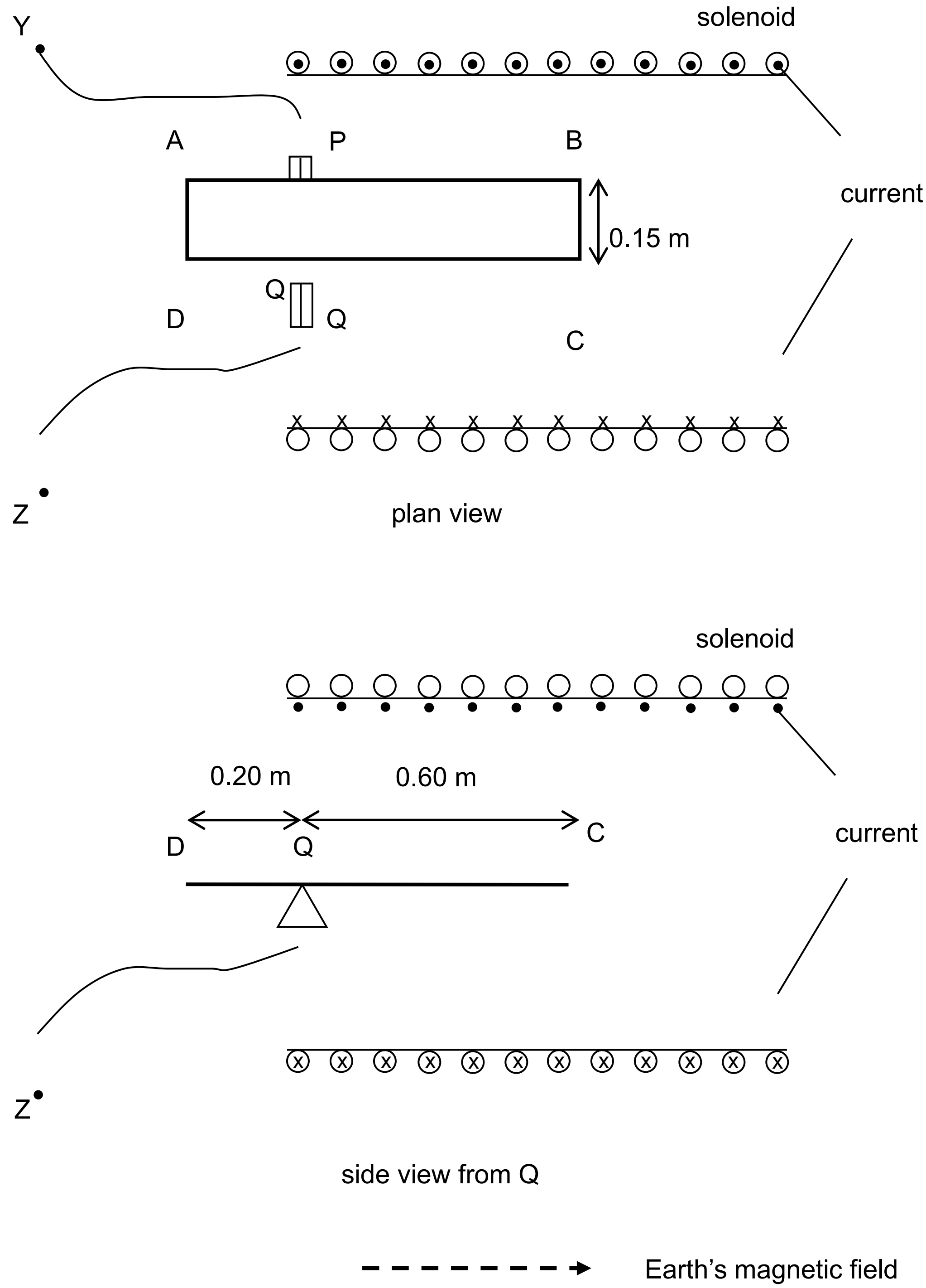

Fig. 5.1

It is given that BC = 0.15 m, DQ = 0.20 m and QC = 0.60 m.

The Earth's magnetic flux density is 5.0×10^{-5} T and in the direction as shown in Fig. 5.1.

When there is no current in the circuit, the frame is horizontal. When a current of 4.0 A passes through ZQCBPY, a small load of 3.0×10^{-4} N has to be hung at the middle of AD so that the frame can remain horizontal.

(i) Show that the magnetic flux density in the solenoid is 1.67×10^{-4} T.

[1]

(ii) Given that the solenoid has 6 turns per cm, determine the current in the solenoid considering the effect of the Earth's magnetic field.

current = …..…………….. A [3]

(b) A uniform magnetic field is produced in the shaded region as shown in Fig. 5.2. The magnetic field is directed out of the plane of the paper. At point P, a gamma-ray photon interaction causes two particles X and Y that are of equal mass and opposite charges with the same magnitude to be formed. The paths of these two particles are shown in Fig. 5.2.

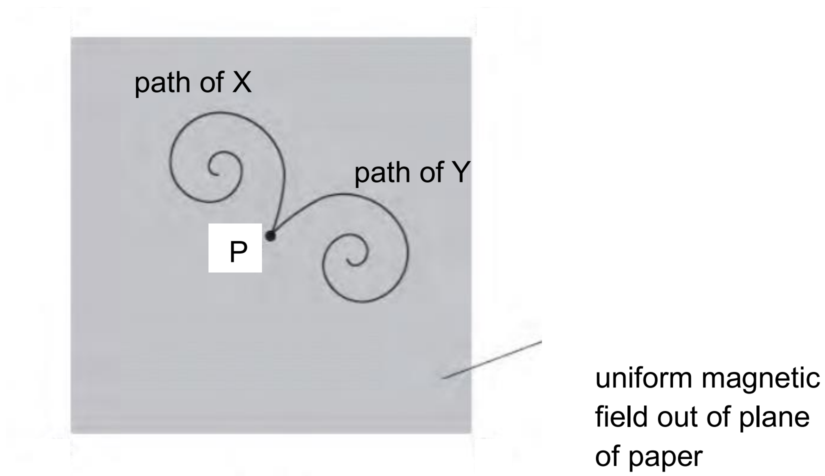

Fig. 5.2

(i) State which particle is the negatively-charged particle.

particle ……………………. [1]

(ii) Suggest, with a reason, why each of the paths is a spiral, rather than arc of a circle.

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……………………………………………………………………………………………....[2]

(iii) State and explain what can be deduced from the paths about the initial speeds of the two particles.

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……………………………………………………………………………………………....[2]

(c) Fig. 5.3 shows two aluminium blades. Blade A is a complete piece whereas blade B has been cut to form a comb.

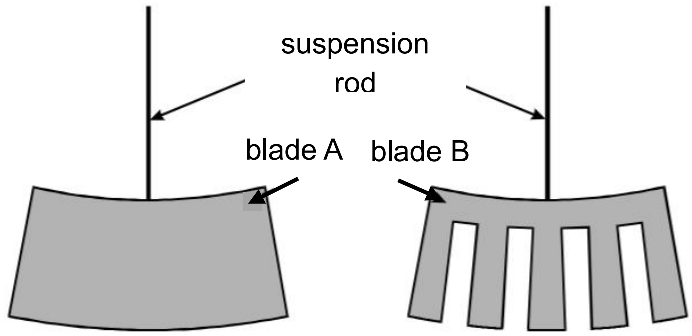

Fig. 5.3

(i) Each plate is suspended in turn between the poles of a strong permanent magnet as shown in Fig. 5.4.

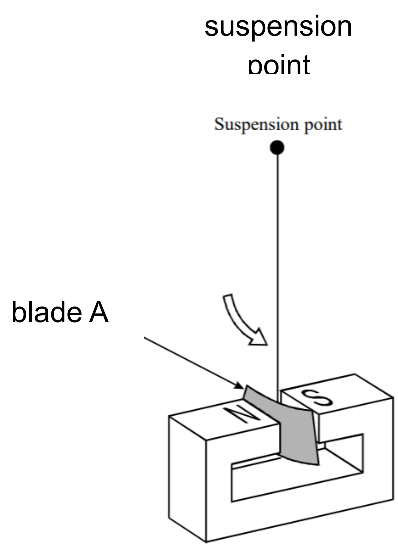

Fig. 5.4

The oscillations of blade A are rapidly damped. Use Faraday's law of electromagnetic induction to explain why the amplitude of the oscillations decreases.

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…………………………………………………………………………………………… [3]

(ii) State which electrical property of blade B is increased as compared to blade A.

property = …………………………… [1]

(iii) Hence, or otherwise, explain why the oscillations of blade B decrease less rapidly as compared to blade A.

……………………………………………………………………………………………………

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……………………………………………………………………………………………...[1]

(d) A rectangular coil measuring 20 mm by 35 mm and having 650 turns is rotating about a horizontal axis which is at right angles to a uniform magnetic field of flux density 2.5×10^{-3} T at a rate of 20 revolutions per second. The plane of the coil makes an angle θ with the vertical as shown in Fig. 5.5.

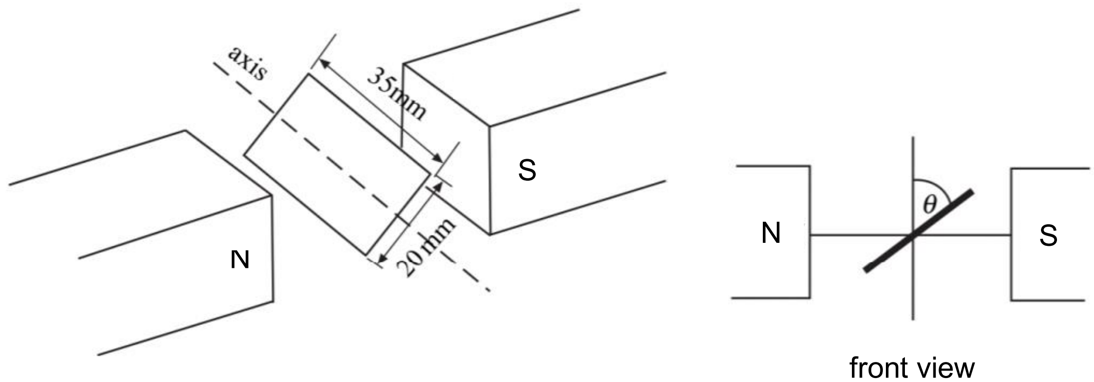

Fig. 5.5

(i) Calculate the magnetic flux linkage through the coil when $\theta = 30°$.

magnetic flux linkage = ……………………………… Wb turns [2]

(ii) Show that the variation with time t of the e.m.f E induced in the coil is given by this equation

$$E = 0.14 \sin 40\pi t$$

given that when $t = 0$, $\theta = 0°$.

[2]

(iii) Fig. 5.6 shows the variation with t of E.

Sketch on the same graph the variation with t of E if the speed of rotation is halved.

E

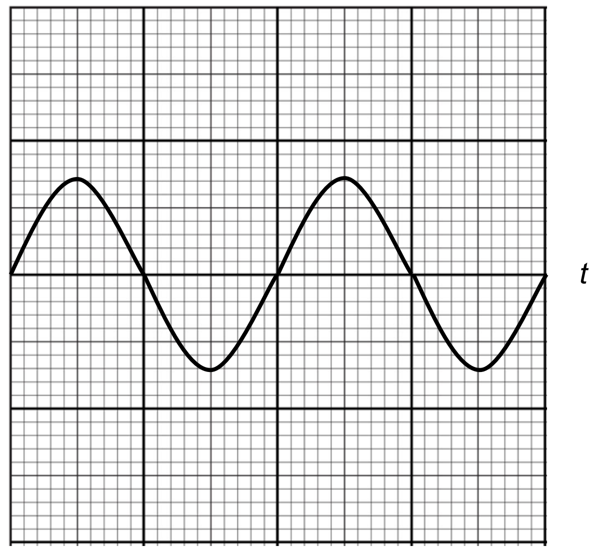

Fig. 5.6

[2]

[Total: 20]