Name : Tan Zhi Yong　　Reg. No. : 0356H　　Date : 19/5/04

National Junior College
Physics Year 2 Topical Quiz
Electromagnetism & Electromagnetic Induction

18 / 25

30 mins

Data:	Gravitational field strength, g = 10 N kg $^{-1}$
	Permeability of a vacuum, $\mu_o = 4\pi \times 10^{-7}$ H m^{-1}

1. **Figure 1** below shows an arrangement used to determine electric current by measuring the force on a current–carrying conductor in a magnetic field.

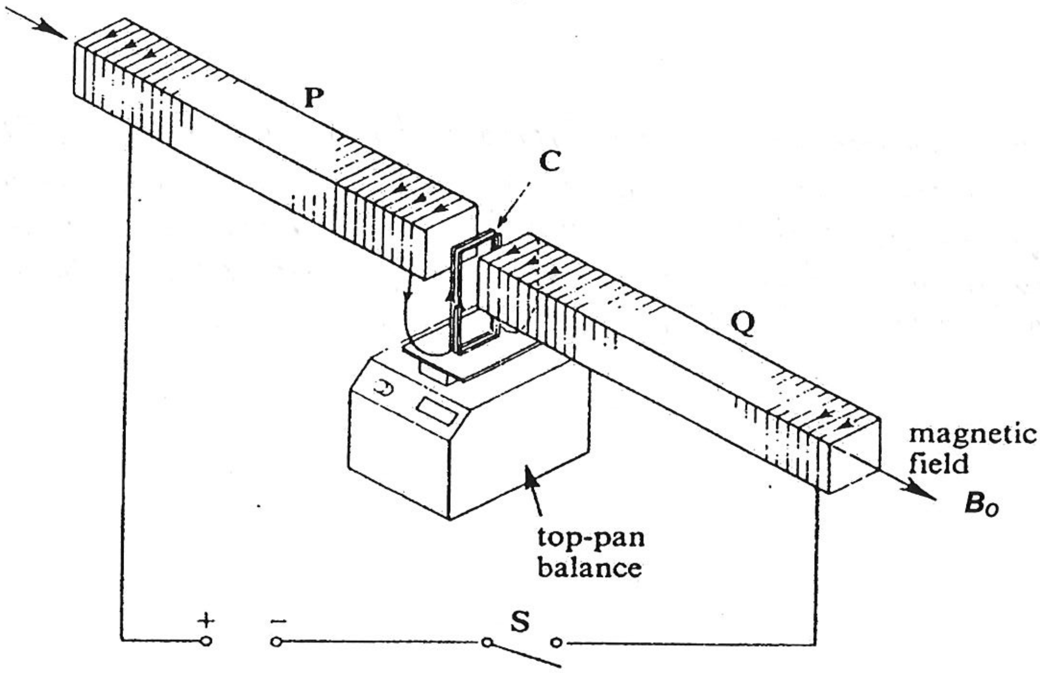


Fig. 1

P and Q are two long thin solenoids with a square cross-sectional area. They have a common axis and are separated by a **small** air gap.

A rectangular coil of wire of 5 turns, C, is placed in the gap and this rests vertically on a top-pan balance which measures mass to the nearest 0.001 g. The solenoids and the coil are in series so that when S is closed, each carries the same current.

(a) Determine the minimum force which the balance can detect. [1]

Min. force = $\frac{0.001}{1000} \times \cancel{9.81}\ 10 = 1.0 \times 10^{-5}$ N

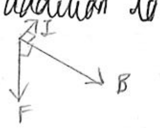
~~$= 9.81 \times 10^{-6}$ N~~

1

(b) When the current is switched on, the current and magnetic field directions are as shown in the diagram.

(i) State and explain the effect on the balance reading when the current is switched on. [2]

By Fleming's left hand rule, there will be a resultant force acting downwards by the coil in addition to its weight. Hence balance reading increases.



(ii) The magnetic flux density at the ***end of one solenoid*** is given the symbol B_O, write down an expression for the magnetic force acting on coil C. [2]

$F_B = N B_0 I L_C$

$NBIL$

$5(2B_0)IL$

$= 10 B_0 I L$

3

1. (b) (iii) When the switch is open, the balance reads 5.005 g. When the switch is closed, the balance reads 5.025 g. The horizontal length of coil C which is in the field is 5.0 cm, and B_O is 3.9×10^{-4} T. What is the current flowing in the circuit? [3]

$F = BIL \sin\theta$

$\frac{(5.025 - 5.005)}{1000}(10) = (3.9 \times 10^{-4})\left(\frac{5}{100}\right)(5I)\,2$

~~$5I = 10.3\,A$ (3s.f)~~

$I = 2.05\,A$ (3s.f)

1.0

ecf

(iv) Describe and explain what happens to the balance reading if a soft iron core is inserted into each solenoid. [2]

The balance reading will increase by a large amount. The soft iron core concentrates the magnetic ~~flux~~ lines in the coil, and has a much higher ~~lower~~ permeability than air, hence the magnetic flux density increases by a great deal. Since $F = BIL \sin\theta$, the ~~to~~ magnetic force increases and balance reading increases.

2. A student investigates the behaviour of a magnetic pendulum. A magnet swings above a coil attached to a counter. A count is made every time the voltage across the terminals changes polarity.

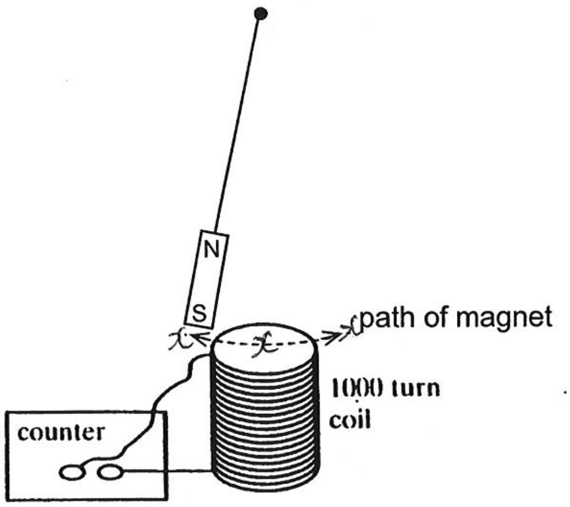


Fig. 2

(a) Explain why

(i) a voltage is induced in the coil. [2]

0

~~By Lenz's law,~~ By principle of conservation of energy, the mechanical work done by the magnet is converted to electrical energy in the coil such as to oppose it so that energy is needed to drive the magnet to the coil. Thus a voltage is induced in the coil. Faraday's law

(ii) the voltage changes polarity. [2]

2

By Lenz's law, the direction of the induced electromotive force is such as to oppose the change in flux. When the magnet is approaching the coil, the induced emf is in a direction that opposes it. When the magnet is leaving the coil, the induced emf is in a direction such that the coil's magnetic flux attracts it. Hence there is a change in polarity of voltage.

(b) Label with an X on **Fig. 2** every position of the magnet where the induced voltage changes polarity. [2]

2

2

2. (c) Write down two changes that could be made to increase the maximum voltage induced in the coil. [2]

$E = -\frac{d\phi}{dt} = -\frac{d}{dt}(NBA\cos\theta)$

1. Increase number of turns of the coil
2. Increase strength of magnet so that it has higher magnetic flux density.

shorten pendulum

invert iron core

increase frequency

3. In an attempt to calibrate a voltmeter, a student used the arrangement as illustrated in **Fig. 3** below.

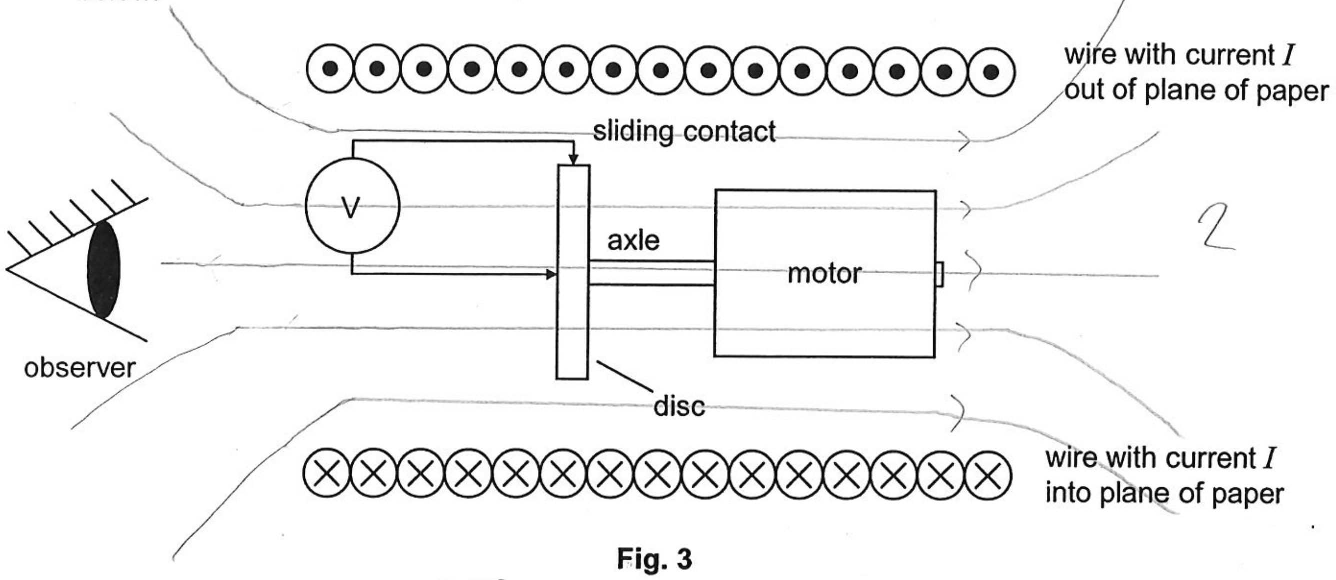


Fig. 3

2

An aluminium disc of radius 50 mm placed at the centre of a long solenoid is spun round 10 rev s^{-1} by a small electric motor.

0.05 m

ω

(Magnetic flux density at the centre of the solenoid, $B = \mu_o nI$;
where n = number of coils of wire per metre; I = current in the coils)

$F = BIL$

$E = \frac{d}{dt}(NBA)$

$E = (2000)(B)(\pi(0.05)^2)$

(a) Sketch on **Fig. 3** the magnetic field pattern in the solenoid due to the current in the coils. [2]

(b) If the solenoid has a length of 1.2 m with 2000 turns of wire and the current in the coil is 2.5 A, show that the magnetic flux density at the disc is 5.2 mT [1]

$B = \mu_0 n I$

$= \frac{(4\pi \times 10^{-7})(2000)(2.5)}{1.2}$

$= 5.2$ mT (shown)

1

(c) Calculate the area the disc sweeps out in 1.0 s and hence determine the potential difference between the perimeter and centre of the disc. [2]

Area per second $= \pi r^2 \times 10$

$= \pi(0.05)^2 \times 10$

$= \cancel{2.5 \times 10^{-3}\pi \text{ m}^3 s^{-1}}\ 0.025\pi \text{ m}^2 s^{-1} = 0.0785 \text{ m}^2 s^{-1}$

1

$E = -\frac{d}{dt}(NBA\cos\theta)$

$B\frac{dA}{dt}$

$= (2000)(5.2 \times 10^{-3})(0.025\pi)$

$= 0.817$ V (3s.f)

4.08×10^{-4}

(d) The disc rotates clockwise when viewed by an observer along the axis of the solenoid as shown in **Fig. 3**. State and explain whether the rim is at a higher or lower potential than the axle. [2]

Axle ~~Rim~~ is at higher potential than rim ~~axle~~ as ~~current~~ by Fleming's right ~~left~~ hand rule, current flows from rim ~~axle~~ to axle ~~rim~~. Thus there is net flow of positive charge from rim ~~axle~~ to axle ~~rim~~ and ~~higher~~ lower potential builds up at rim ~~axle~~.

I B F

6

END