: ____________________ Reg. No. : ____________ Date : ____________

ELECTROMAGNETIC INDUCTION – WEB ACTIVITIES

. are to explore this exercise by 22^{nd} May.
uggested answers will be published on NJC Physics Website on 26^{th} May.

A. AC GENERATORS

Instructions: i. View the animation on the following website:
http://www.wvic.com/how-gen-works.htm
ii. Use the animation to help you answer the following questions.

1. Explain, in terms of Faraday's Law and Lenz's Law, why and how current flows in the circuit when the coil rotates.

2. State and explain the effect on the induced emf when the following changes are made:
(a) Direction of rotation of coil

(b) Rate of rotation of coil

3. Describe two other ways to change the magnitude of the induced emf.

B. MagLev Trains

Visit the following website and answer the questions below:
http://www.hk-phy.org/articles/maglev/maglev_e.html

1. What are the advantages of MagLev trains over conventional trains?

2. Explain how the Japanese technology of Electrodynamics Suspension System "utilizes the principle of electromagnetic induction" to levitate a train.

3. With reference to Fig 4 (a) and (b) in the above **website**, explain why "both halves of the coils generate an upward component of magnetic force on the superconducting magnet" when current induced flows in the direction shown.

4. Referring to Fig 2, describe using Laws of Electromagnetic Induction what happens to the coils in the guidance rails as the train's guidance electromagnet move nearer towards it. Hence explain how the guidance system help the train move in a straight path.

Group Discussion on Electromagnetic Flowmeter

Read the following passage and answer the questions that follow.

If a conducting liquid flows through a magnetic field, the conditions exist for an e.m.f to be set up across the liquid. This principle is used in electromagnetic flow meters to measure the rate of flow of liquid along a pipe. A diagram of this type of flowmeter is given below. As the liquid flows through the tube it cuts the magnetic field set up by the field winding coils, causing an e.m.f. E_1 to be induced. This e.m.f. is sensed by two electrodes X and Y which are opposite each other and in contact with the liquid at right angles to the axis of the magnetic field.
In addition, there is a flux sensing coil which gives an output E_2 which is directly proportional to the magnetic flux density.

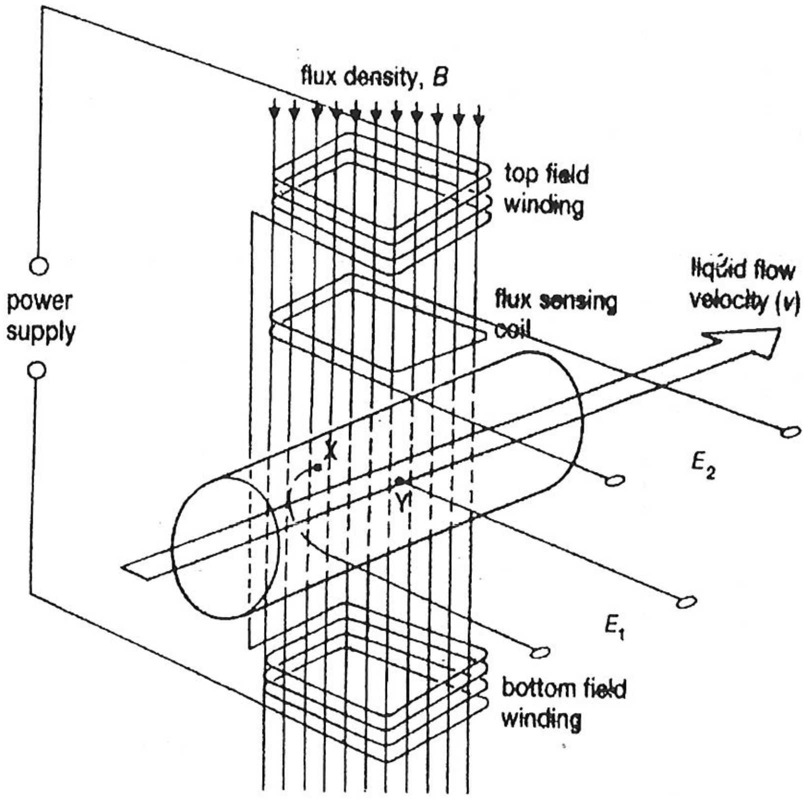


Diagram to explain the principle of electromagnetic flow metering

(a) Why does the pipe, in the vicinity of the electrodes, have to be non-conducting? [1]

(b) Given that, $E_1 = Bvd$, where v is the liquid flow velocity and d is the internal diameter of the pipe, show that $v = k(E_1/E_2)$, where k is a constant. [2]

(c) What is the value of E_1 for a liquid travelling along a pipe of internal diameter 65 mm with velocity 0.73 ms^{-1} when $B = 0.35$ T? [2]

(d) The conductivity of the liquid used in a flowmeter is usually very small. Only one of the following liquids is unsuitable. Make a reasoned guess as to which of these liquids does not conduct sufficiently: *blood, hydrocarbons, drinking water and nitric acid.* [1]

(e) What is the advantage of using platinum electrodes? [1]

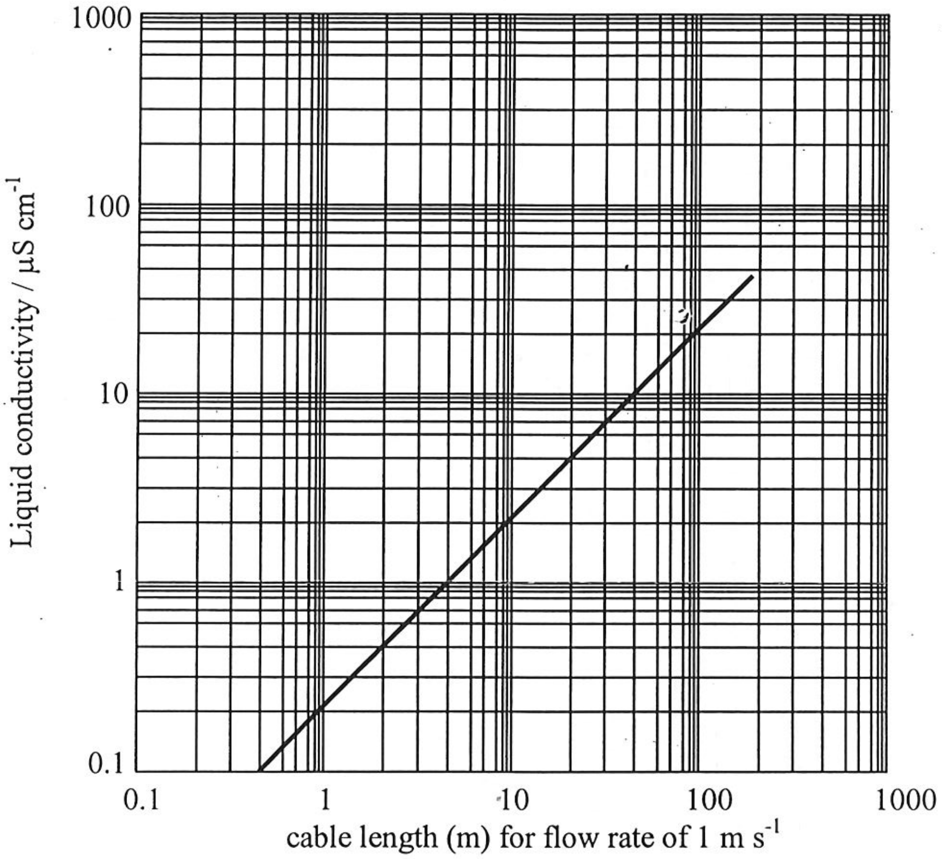
(f) Why does E_2 become zero if the power supply is d.c.? [1]

(g) How does using a.c. overcome this problem? [1]

(h) Suggest an alternative method, other than using the flux sensing coil as above, to measure the magnetic flux density B. [1]

(i) What liquid speed, in ms^{-1}, would you expect a flowmeter to read on a 450 mm bore pipe if liquid passes through the pipe at a rate of 200 m^3h^{-1}? How can this type of calculation enable a flowmeter to be calibrated? What assumptions are you making? [3]

(j) The figure below shows a graph of conductivity of the liquid in use plotted against usable cable length from electrodes to measuring instrument.



(1) Suggest a reason for plotting conductivity and cable length values on a logarithmic rather than linear scale. [1]

(2) Estimate the maximum cable length which can be used with a liquid of conductivity 4 μScm^{-1}. [1]

(m) What effect, if any, could the following have on the system?

(1) Air getting into the pipe. Why is it preferable to mount the meter in a vertical rather than a horizontal pipe? [2]

(2) Solids transported in the moving liquid. [1]

(n) Suggest:

(1) one industrial application of the electromagnetic flowmeter, and [1]

(2) one advantage that electromagnetic flowmeter has over conventional flowmeter (such as the Venturi meter) to measure liquid flow rates. [1]

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a) If it is conducting, it will concentrate the magnetic field lines and prevent them from passing through the liquid.

b)
$$E_1 = Bvd \text{ --- (1)}$$
$$E_2 \propto B$$
$$E_2 = bB \text{ --- (2) where } b \text{ is a constant}$$
$\frac{(1)}{(2)}$:
$$\frac{E_1}{E_2} = \frac{vd}{b}$$
$$V = \frac{b}{d}\left(\frac{E_1}{E_2}\right)$$
$$= k\left(\frac{E_1}{E_2}\right) \text{ where } k \text{ is a constant}$$

c)
$$E_1 = Bvd$$
$$= 0.35 \times 0.73 \times \frac{65}{1000}$$
$$= 0.0166 \text{ V (3s.f)}$$

d) Hydrocarbons. They conduct very little electricity as they are ~~non-polar molecules~~ incapable of becoming or producing charged particles.

e) Platinum ~~does not~~ is resistant to acid corrosion.

f) D.C does not allow a constant change in flux linkage as direction of current is constant.

g) A.C changes direction periodically and hence flux linkage induced in the coil is continuously changing, ~~producing~~ inducing an electromotive force.

h) ~~Place a wire of certain length~~

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i) Radius $= \frac{450}{1000 \times 2}$

$= 0.225 m$

Cross-sectional area $= \pi (0.225)^2$

$= 0.1590 m^2$

Liquid speed $= \frac{200}{0.1590}$

$= 1260 ms^{-1}$ (3s.f)

$V = k \frac{E_1}{E_2}$

Readings of E_1 and E_2 can be taken, followed by ~~reading~~ calculation of V and hence value of k can be determined.

Assumption is liquid is non-compressible.

j) 1. Values are too large to be plotted on a linear scale.

2. Max cable length $= 20 m$ (2s.f)

m) 1. Air can be compressed, hence rate of flow will be ~~error~~ measured inaccurately. ~~Air is not compressed as much in a vertical pipe due to absence of~~ In vertical pipe, lower density of air enables it to rise to the top of liquid and prevent it from interfering in measurement of v.

2. Solids will hinder flow of liquid and slow it down.

n) 1. Measure of rate of flow of oil in pipelines.

2. Does not slow down rate of liquid flow.