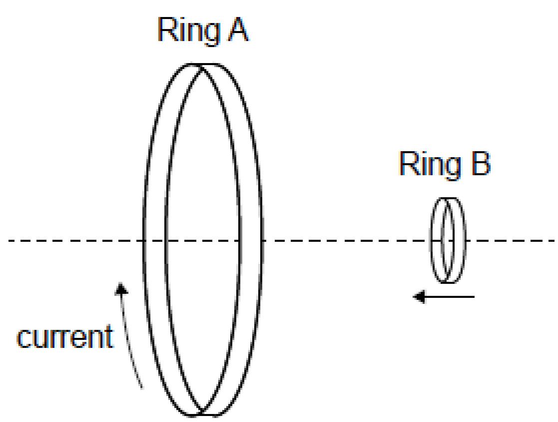
Paper 2 Summary Qs - EM Induction & Rotational Dynamics

[41 marks]

1. [Maximum mark: 7] SPM.2.HL.TZ0.5

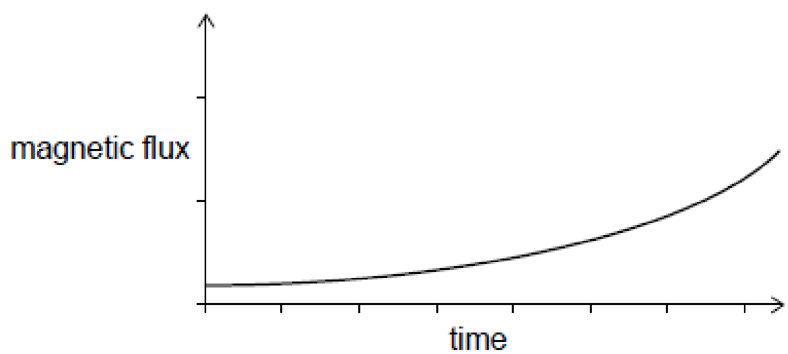
Two conducting rings, A and B, have their centres on the same line. The planes of A and B are parallel. There is a constant clockwise current in A. Ring A is stationary and ring B moves towards ring A at a constant speed.



(a) Outline why the magnetic flux in ring B increases. [1]

(b) State the direction of the induced current in ring B. [1]

(c) The graph shows how the magnetic flux in ring B varies with time.

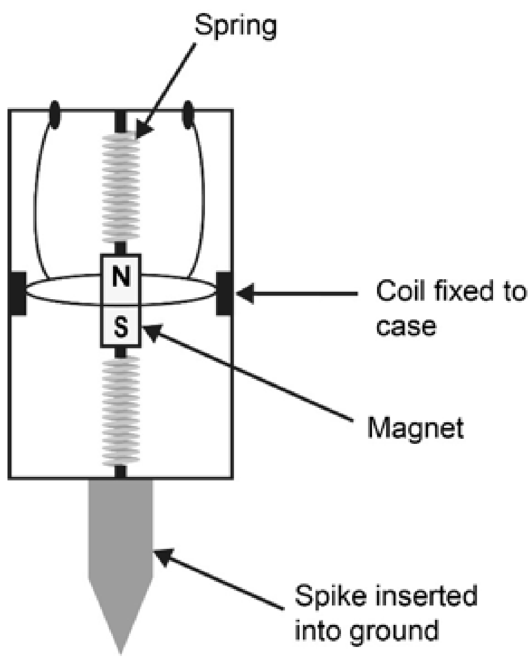


Discuss the variation with time of the induced current in ring B. [3]

(d) Outline why work must be done on ring B as it moves towards ring A at a constant speed. [2]

2. [Maximum mark: 20] EXE.2.HL.TZ0.2

A geophone is an instrument designed to measure the movement of ground rocks.



When the ground moves, the magnet-spring system oscillates relative to the coil. An emf is generated in the coil. The magnitude of this emf is proportional to the speed of the magnet relative to the coil.

(a.i) State the movement direction for which the geophone has its greatest sensitivity. [1]

(a.ii) Outline how an emf is generated in the coil. [2]

(a.iii) Explain why the magnitude of the emf is related to the amplitude of the ground movement. [3]

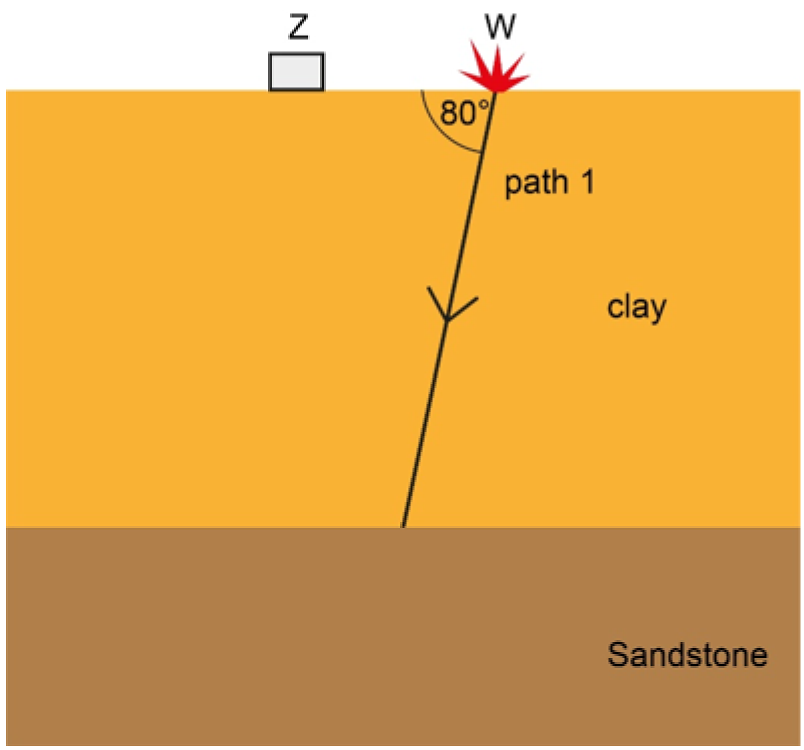
(a.iv) In one particular event, a maximum emf of 65 mV is generated in the geophone. The geophone coil has 150 turns.

Calculate the rate of flux change that leads to this emf. [2]

(b) Suggest **two** changes to the system that will make the geophone more sensitive. [4]

The geophone is mounted on the ground at point Z and an explosion is produced at point W some distance away. Sound from the explosion travels to the geophone via the clay layer in the ground.

Diagram not to scale



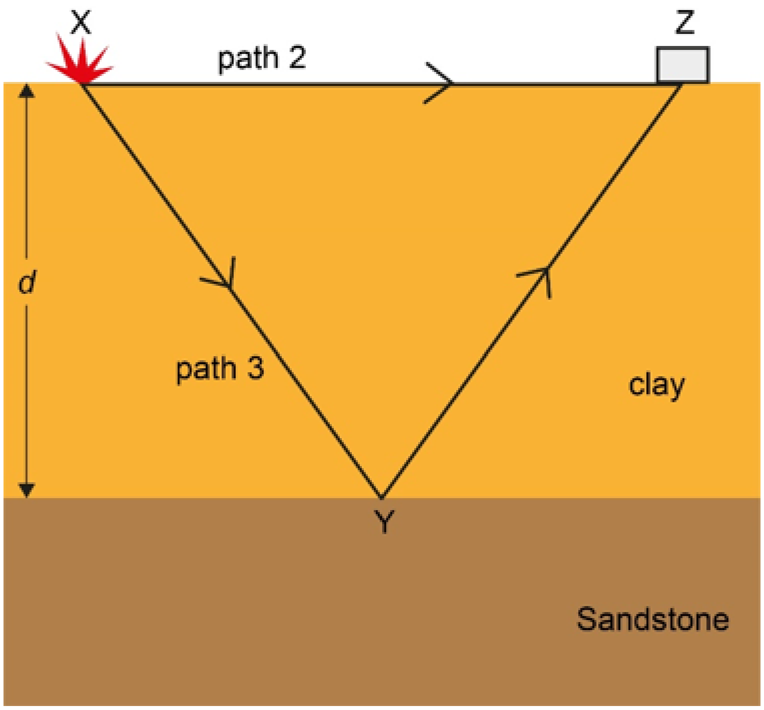
The speed of sound in clay is 3.00 km s^{-1}; the speed of sound in sandstone is 4.70 km s^{-1}

(c.i) Show that, when sound travels from clay to sandstone, the critical angle is approximately 40°. [2]

(c.ii) The angle between the clay–air surface and **path 1** is 80°.

Draw, on the diagram, the subsequent path of a sound wave that travels initially in the clay along **path 1**. [2]

Another explosion is produced at X. The sound from this explosion is detected twice at the geophone at Z. Some sound travels directly from X to Z through clay along **path 2**. Other sound travels through clay via Y along **path 3**.



The vertical thickness of the clay layer is *d*. The distance XZ is 80.0 m.

The time between the arrival of the sounds due to the path difference is 6.67 ms.

(d) Calculate *d*. [4]

3. [Maximum mark: 7] EXE.2.HL.TZ0.8

A ring of mass $M = 0.32$ kg and radius $R = 0.25$ m is accelerated from rest by a constant torque of 0.20 N m. The moment of inertia of the ring is MR^2.

(a) Calculate:

(a.i) the angular acceleration of the ring; [2]

(a.ii) the angular velocity of the ring after a time of 5.0 s. [1]

(b) A solid disc of the same mass and radius as the ring is accelerated by the same torque. Compare, without calculation:

(b.i) the angular impulse delivered to the disc and to the ring during the first 5.0 s. [2]

(b.ii) the final kinetic energy of the disc and the ring. [2]

4. [Maximum mark: 7] EXE.2.HL.TZ0.9

The propellor of an model plane is driven by an electric motor that is mounted inside the plane. This propellor is modelled as a rod rotating about an axis through the centre of the rod at right angles to the length of the rod. The moment of inertia for such a rod is $\frac{1}{12}ML^2$ where M is the mass of the rod and L is the total length of the rod.

(a) For the propellor, $L = 5.0\,\mathrm{cm}$ and $M = 0.035\,\mathrm{kg}$.

Calculate the moment of inertia of the propellor. [1]

(b) The propellor is at rest when the electric motor is switched on. The net average torque acting on the propellor due to the motor and resistive forces is $3.5 \times 10^{-2}\,\mathrm{kg\,m^2\,s^{-2}}$. The final speed of the propellor is 190 revolutions per second.

(b.i) Calculate the angular impulse that acts on the propellor. [2]

(b.ii) Calculate, using your answer to (b)(i), the time taken by the propellor to attain this rotational speed. [2]

(b.iii) State and explain the effect of the angular impulse on the body of the aeroplane. [2]

© International Baccalaureate Organization, 2025