

Name of the Student: \_\_\_\_\_

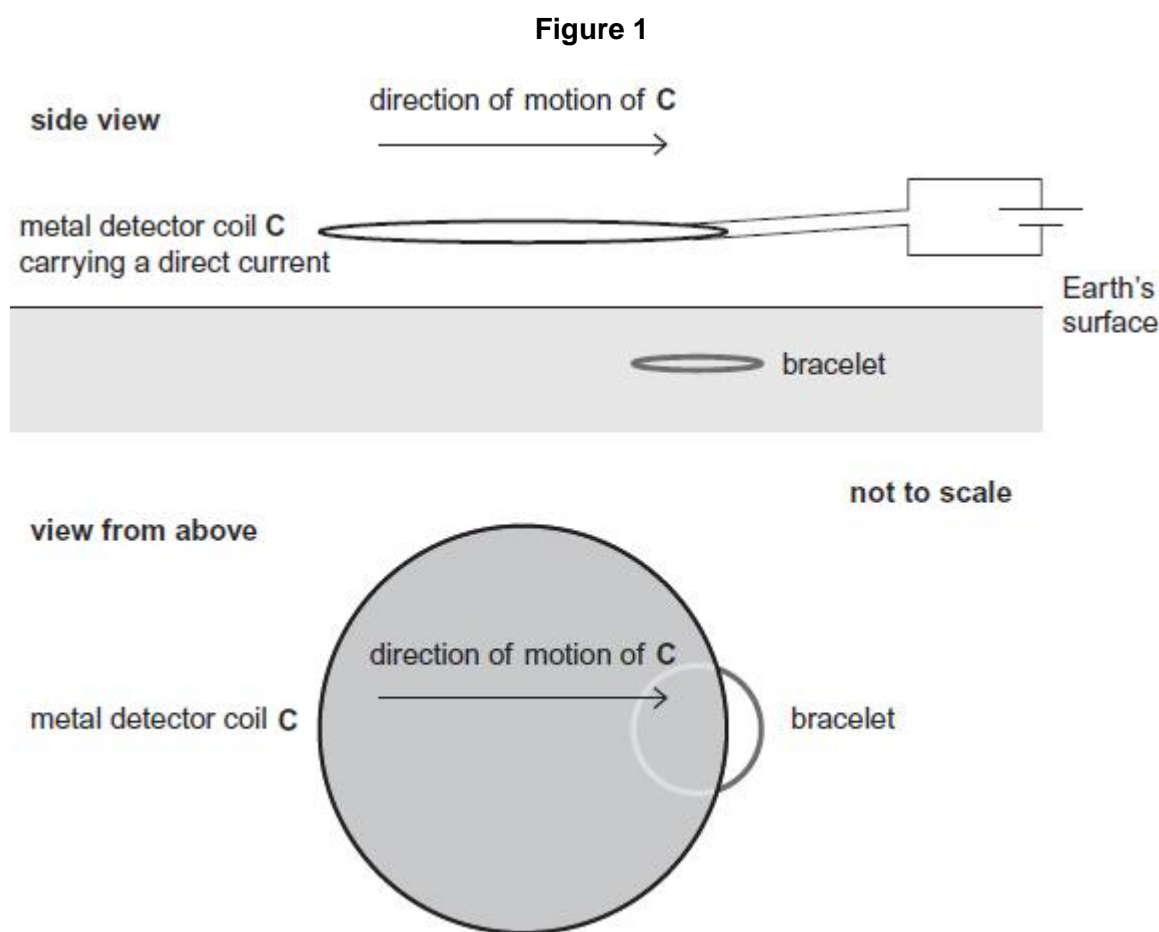
Max. Marks : 23 Marks

Time : 23 Minutes

**Q1.**

A metal detector is moved horizontally at a constant speed just above the Earth's surface to search for buried metal objects

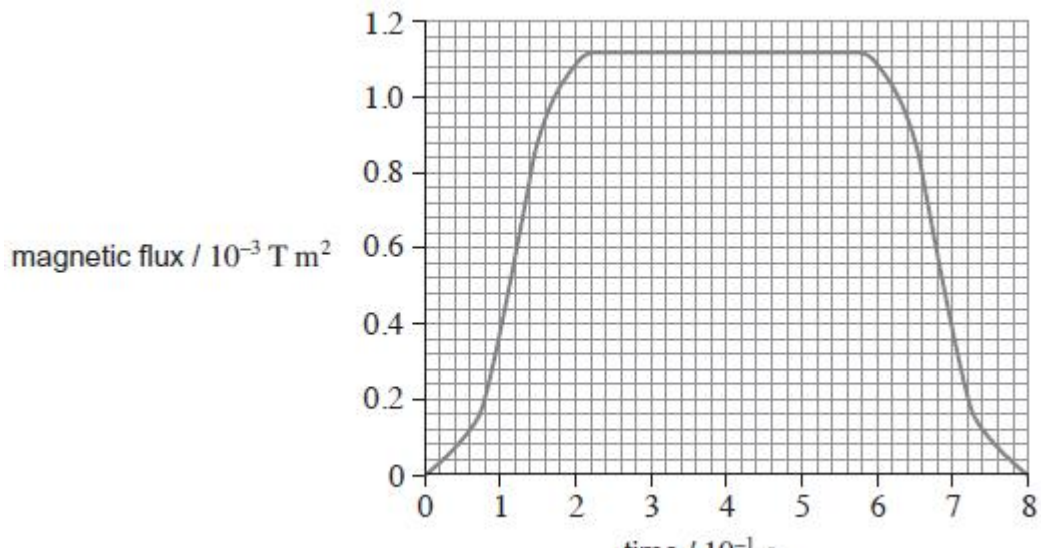
**Figure 1** shows the coil **C** of a metal detector moving over a circular bracelet made from a single band of metal. The planes of the coil and the bracelet are both horizontal.



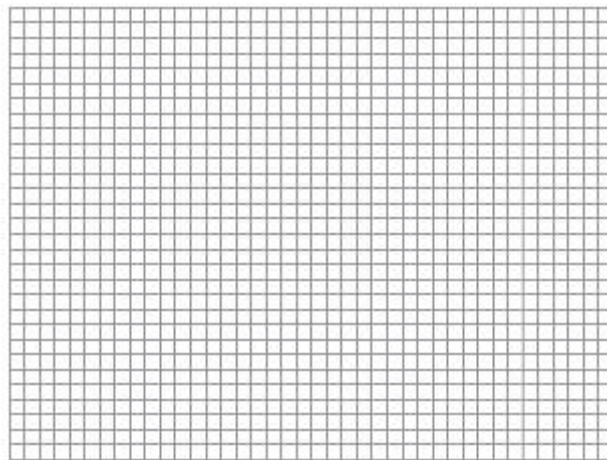
In this metal detector, **C** carries a direct current so that the magnetic flux produced by **C** does not vary. The bracelet is just below the surface, so the flux is perpendicular to the plane of the bracelet. The field is negligible outside the shaded region of **C**.

**Figure 2** shows how the magnetic flux through the bracelet varies with time when **C** is moving at a constant velocity.

**Figure 2**



- (a) (i) Sketch a graph on the grid to show how the emf induced in the bracelet varies with time as **C** moves across the bracelet. Use the same scale on the time axis as in **Figure 2**.



(3)

- (ii) Use the laws of Faraday and Lenz to explain the shape of your graph.

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(4)

(b) The velocity at which **C** is moved is  $0.28 \text{ m s}^{-1}$ .

Show that the diameter of the bracelet is about 6 cm.

(1)

(c) Determine the magnetic flux density of the field produced by **C** at the position of the bracelet.

magnetic flux density \_\_\_\_\_ T

(2)

(d) Determine the maximum emf induced in the bracelet.

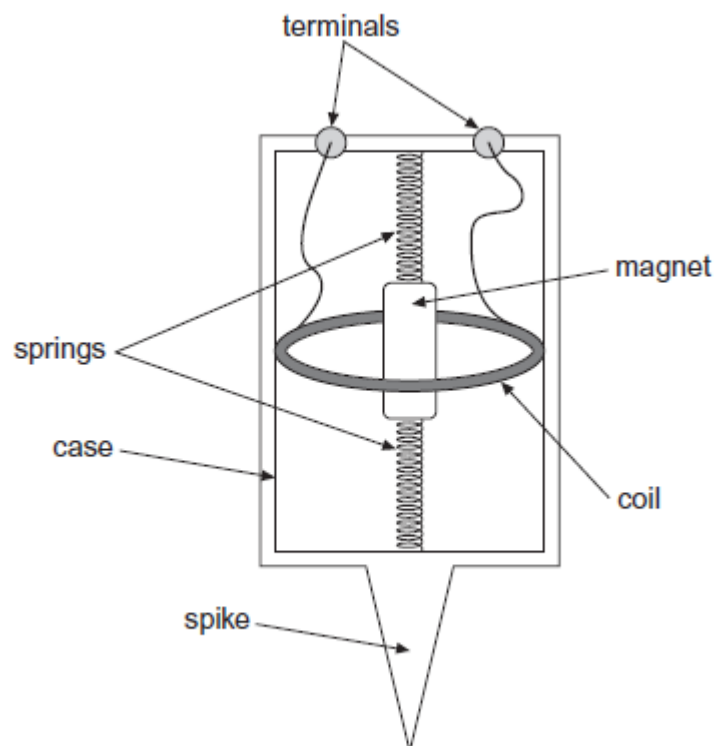
maximum emf \_\_\_\_\_ V

(3)

(Total 13 marks)

## Q2.

The diagram below shows the main parts of a geophone.



The spike attaches the geophone firmly to the ground. At the instant an earthquake occurs, the case and coil move upwards due to the Earth's movement. The magnet remains stationary due to its

inertia. In 3.5 ms, the coil moves from a position where the flux density is 9.0 mT to a position where the flux density is 23.0 mT.

- (a) The geophone coil has 250 turns and an area of  $12 \text{ cm}^2$ .

Calculate the average emf induced in the coil during the first 3.5 ms after the start of the earthquake.

emf \_\_\_\_\_ V

(3)

- (b) Explain how the initial emf induced in the coil of the geophone would be affected:

if the stiffness of the springs were to be increased

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if the number of turns on the coil were to be increased.

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(2)

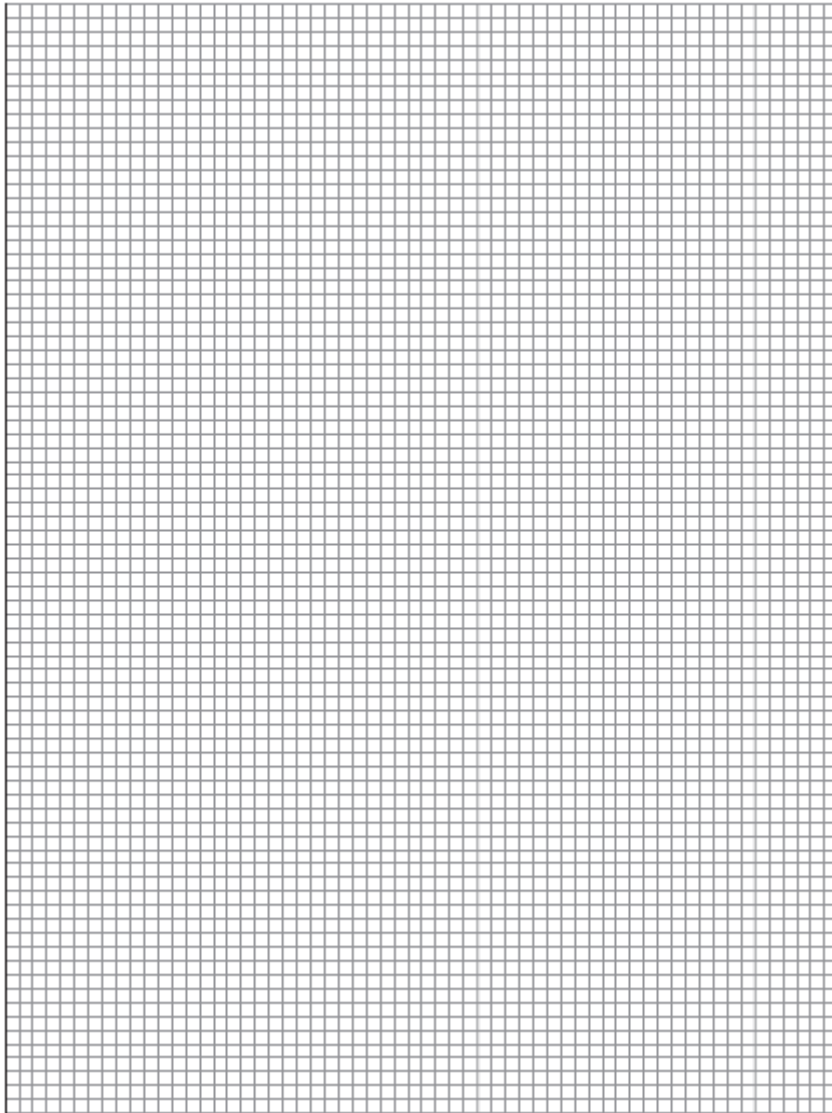
- (c) (i) The geophone's magnet has a mass of  $8.0 \times 10^{-3} \text{ kg}$  and the spring stiffness of the system is  $2.6 \text{ N m}^{-1}$ .

Show that the natural period of oscillation of the mass-spring system is approximately 0.35 s.

(2)

- (ii) At the instant that the Earth stops moving after one earthquake, the emf in the coil is at its maximum value of +8 V. The magnet continues to oscillate.

On the grid below, sketch a graph showing the variation of emf with time as the magnet's oscillation decays.  
Show at least **three** oscillations.



(3)  
(Total 10 marks)