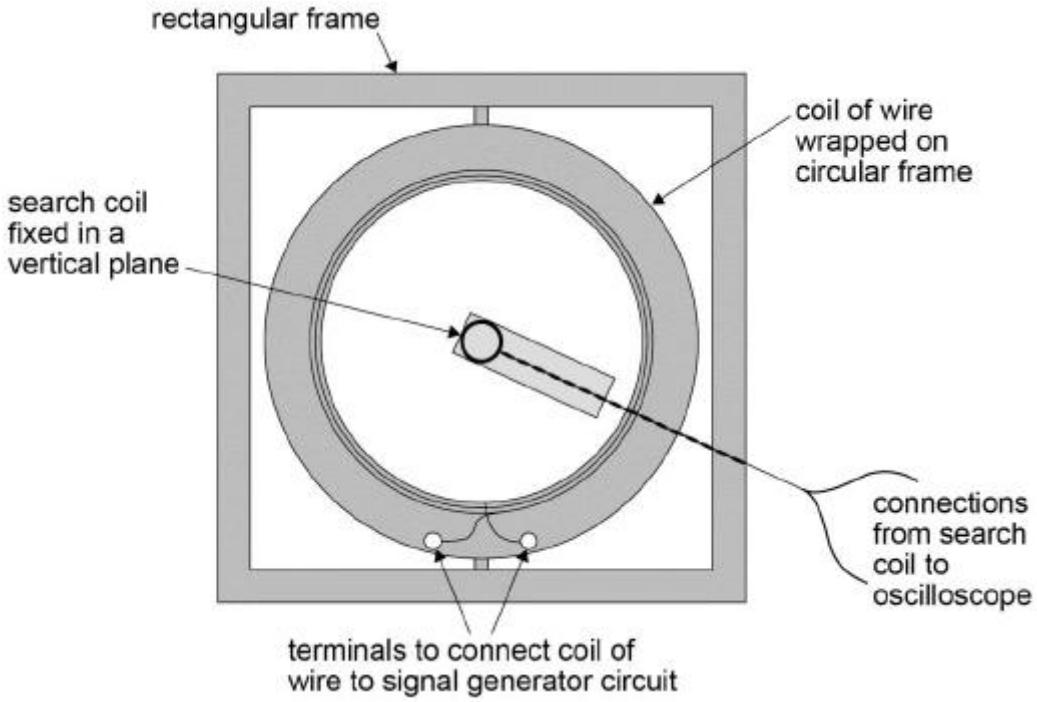
Name of the Student:_____
Max. Marks : 20 Marks **Time : 20 Minutes**

Q1.

This question is about experiments to investigate the magnetic flux density around a current−carrying conductor.

A student is provided with apparatus shown in **Figure 1**.

Figure 1



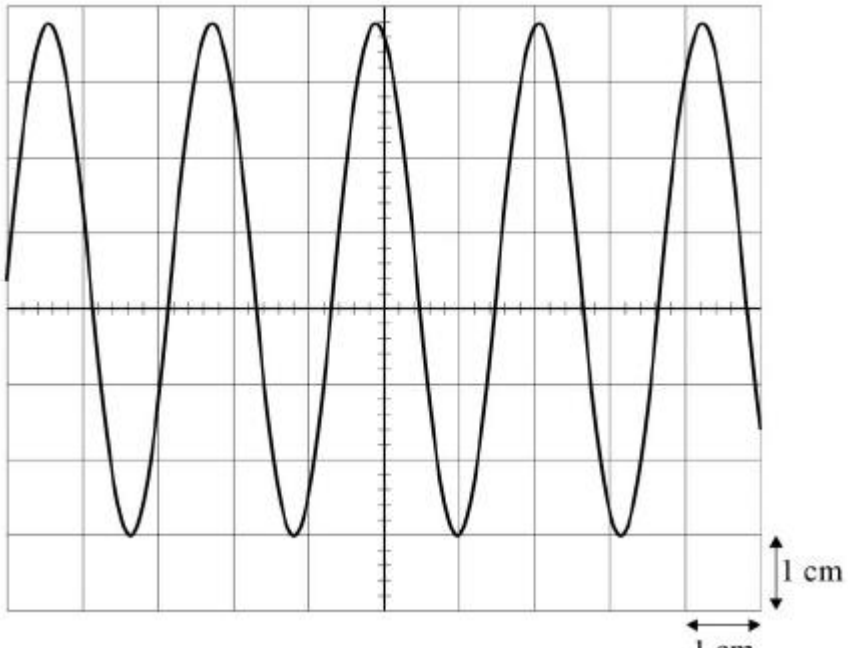
The apparatus consists of a circular frame on which is wound a coil of wire. This arrangement is mounted inside a rectangular frame.

The student clamps a search coil so it is co−axial with the circular coil then arranges the apparatus so that both frames and the search coil lie in the same vertical plane.

The coil of wire is connected to a signal generator and the search coil is connected to an oscilloscope. When a sinusoidal alternating current is passed through the coil an alternating emf is induced in the search coil.

The induced emf displayed on the oscilloscope is shown in **Figure 2**.

Figure 2



(a) Determine, using **Figure 2**, the frequency of the current in the coil.

Time−base setting of the oscilloscope is 0.2 ms cm^{-1}.

frequency = _____ Hz

(2)

(b) Determine, using **Figure 2**, the root mean square (rms) voltage of the emf induced in the search coil.

y−voltage gain of the oscilloscope = 10 mV cm^{-1}

rms voltage = _____ V

(2)

(c) **Figure 3** and **Figure 4** show the search coil and B_{peak}, the peak magnetic flux density produced by the current in the circular coil, when the apparatus is viewed from above.

Figure 3 shows the direction of B_{peak} when the search coil is arranged as in **Figure 1**.

Figure 4 shows the direction of B_{peak} when the circular frame is rotated through an angle θ.

The shaded area in these diagrams shows how the flux linked with the search coil changes as the circular coil is rotated.

Figure 3

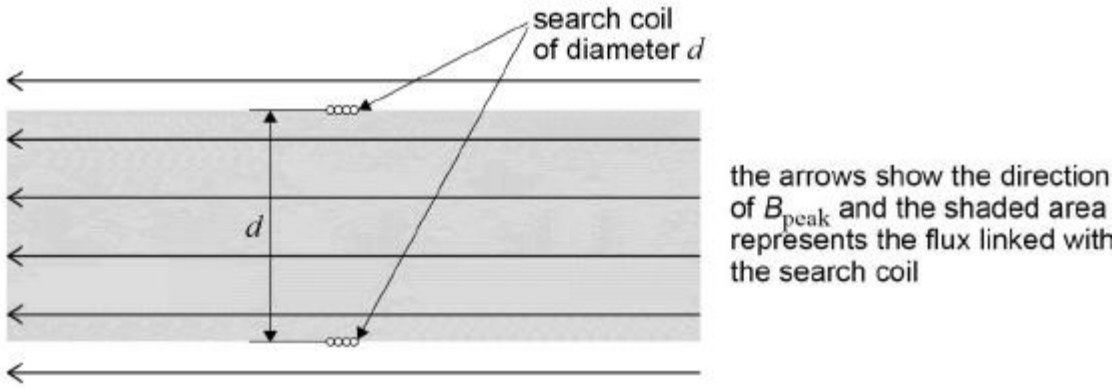
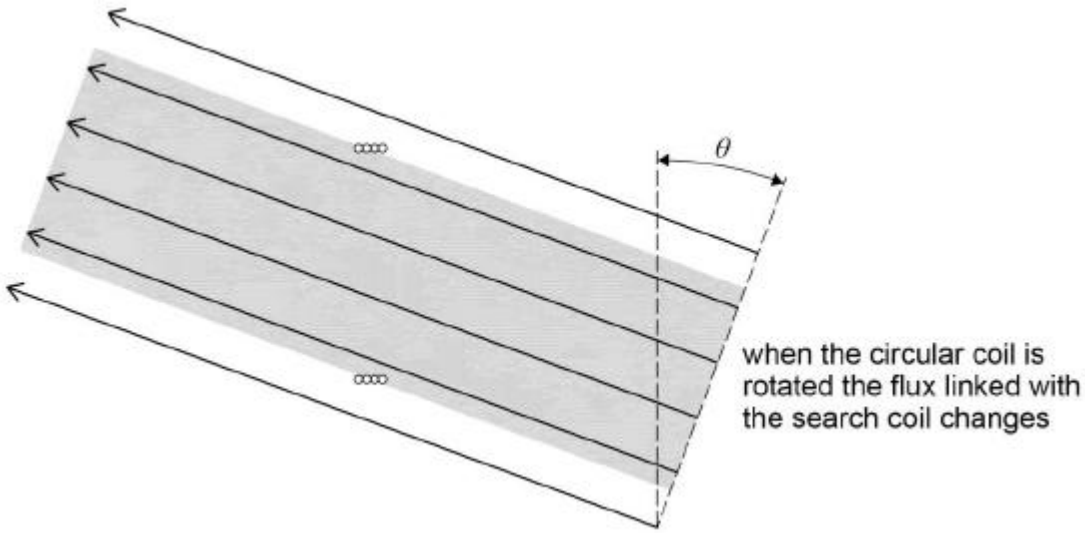


Figure 4



Explain why the flux linked with the coil is directly proportional to $\cos\theta$.

_____

_____

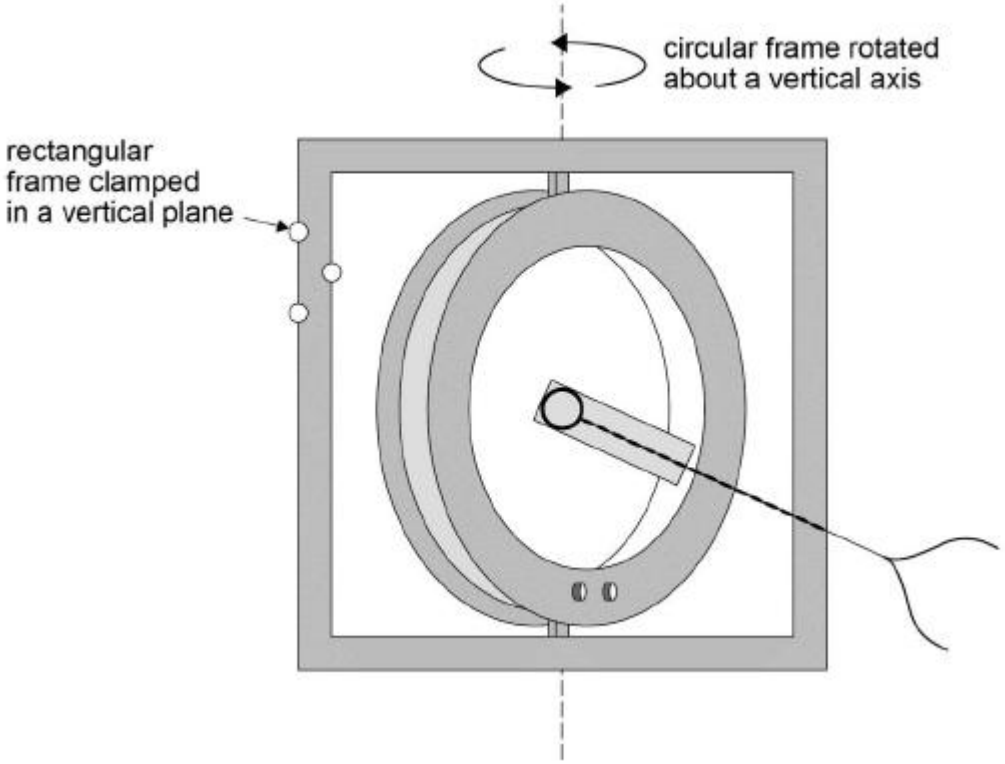
_____

_____

(2)

(d) The student clamps the rectangular frame so that it remains in a vertical plane. Without changing the position of the search coil she rotates the circular frame about a vertical axis so that it is turned through an angle, as shown in **Figure 5**.

Figure 5

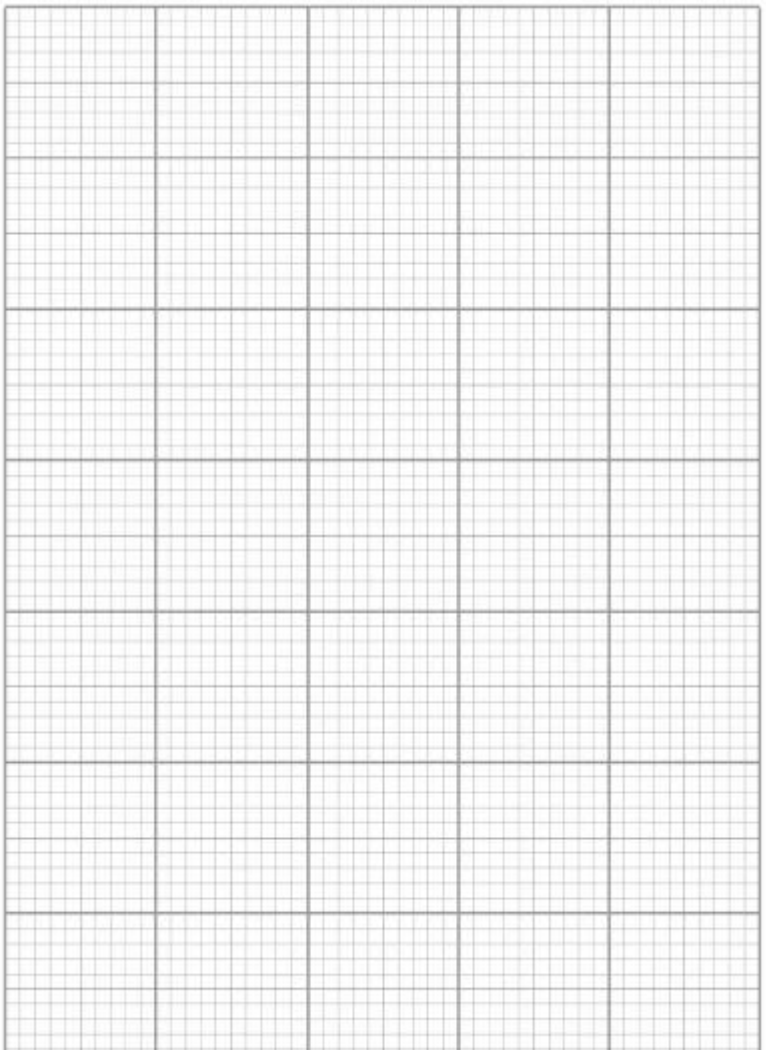


She turns off the time−base on the oscilloscope so that a vertical line is displayed on the screen. Keeping the y−voltage gain at 10 mV cm^{-1} she records the length l of the vertical line and the angle θ through which the circular frame has been rotated. She measures further results for l as θ is increased as shown in the table below.

θ/degree	l/cm	cosθ
10	6.7	
34	5.6	
50	4.4	
60	3.4	
72	2.1	
81	1.1	

Plot on **Figure 6** a graph to test if these data confirm that l is directly proportional to cosθ. Use the additional column in **Table 1** to record any derived data you use.

Figure 6



(4)

(e) State and explain whether the graph you have drawn confirms the suggestion that l is directly proportional to $\cos\theta$.

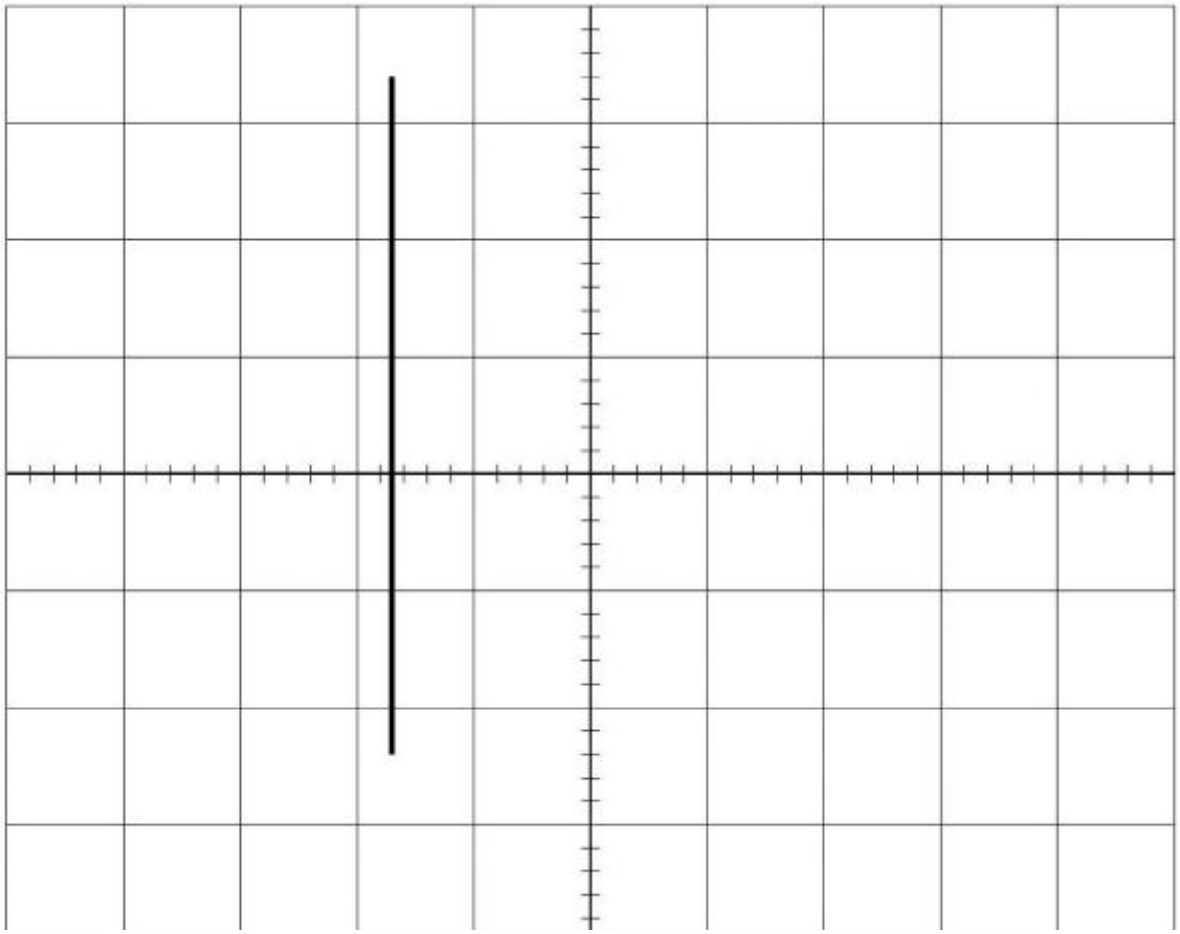
_____

_____

(1)

(f) When the time−base is switched off, the trace on the oscilloscope appears as shown in **Figure 7**.

Figure 7



Describe **two** adjustments the student should make to the trace to reduce the uncertainty in l.

You should refer to specific controls on the oscilloscope. You may use **Figure 7** to illustrate your answer.

(4)

(g) The student adjusts the signal generator so that the frequency of the current in the circular coil is doubled.

State and explain any changes she should make to the settings of the oscilloscope in part **(f)** so that she can repeat the experiment.

_____

_____

_____

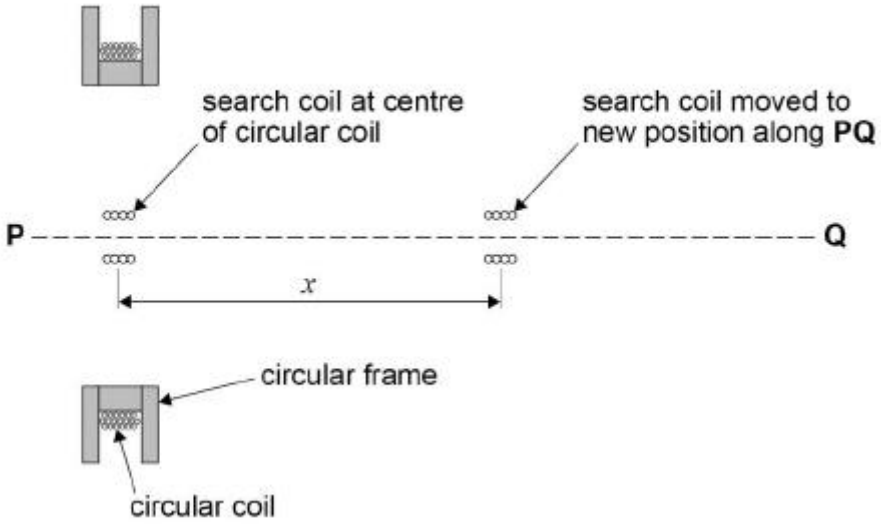
_____

(3)

(h) The apparatus is re−arranged as in **Figure 1** so that both coils lie in the same vertical plane and are co-axial along a line **PQ**.

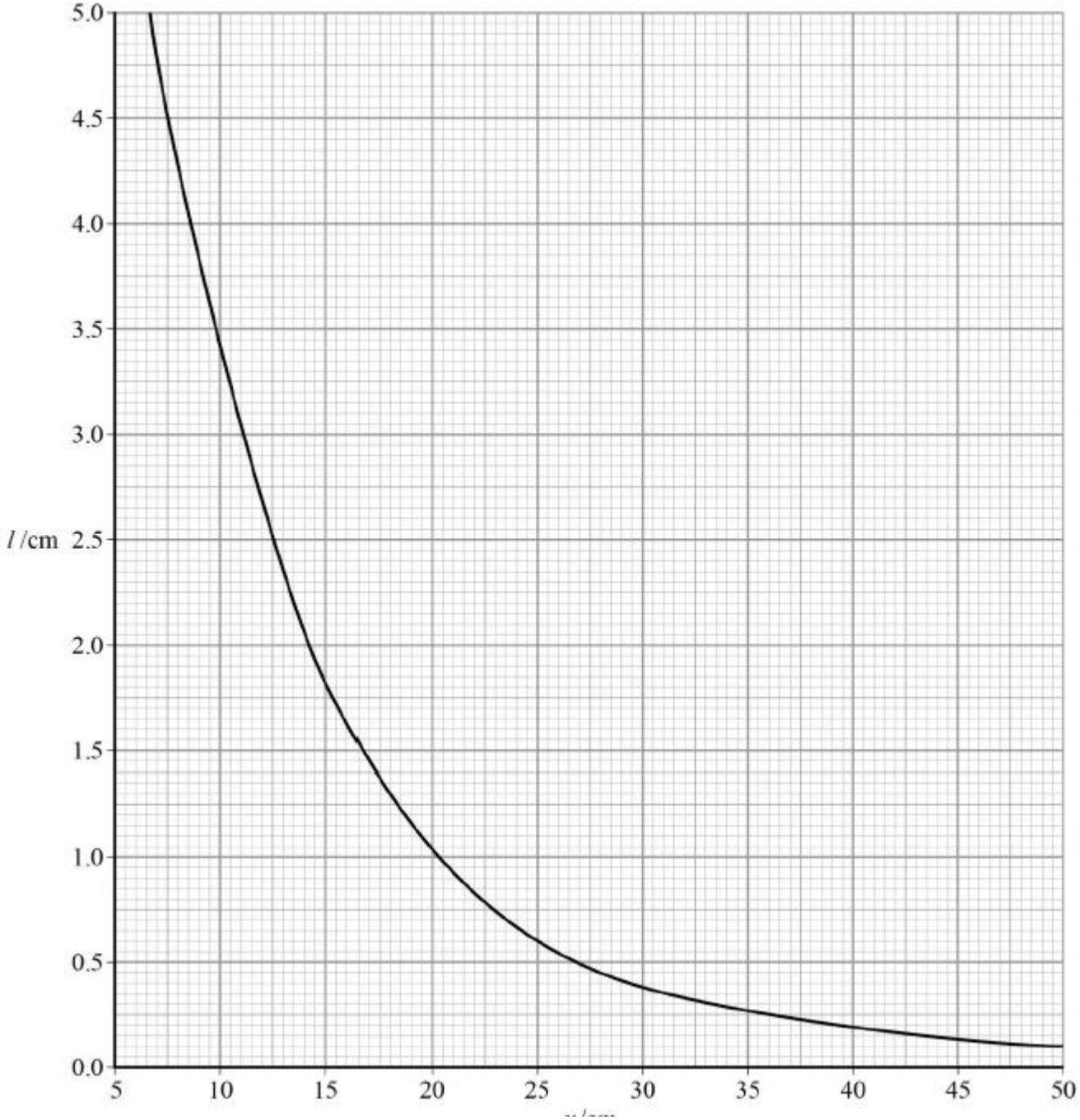
The search coil is then moved a distance x along **PQ**, as shown in **Figure 8**.

Figure 8



The values of l corresponding to different values of x are recorded. A graph of these data is shown in **Figure 9**.

Figure 9



It is suggested that l decreases exponentially as x increases.

Explain whether **Figure 9** supports this suggestion.

_____

_____

_____

_____

(2)
(Total 20 marks)