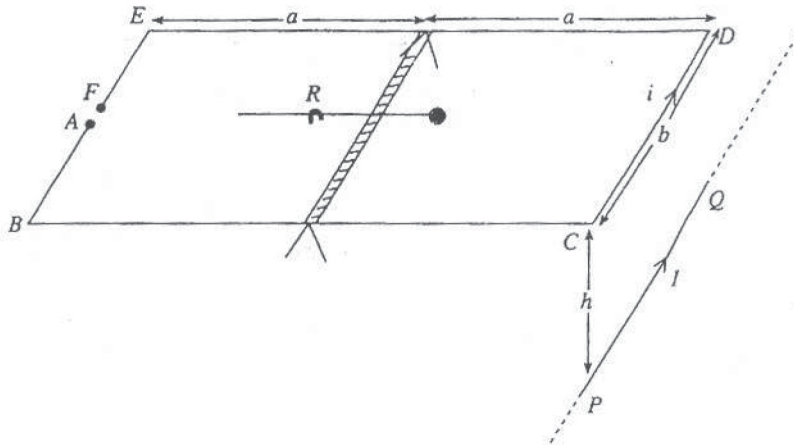


2006 A/L Structured Essay Question No (04)



The figure shows a set-up of a current balance made of a rigid rectangular wire frame  $ABCDEF$  made in such a way that the ends of the wire  $A$  and  $F$  are not in contact with each other. A light strip of insulating material which carries a rider arrangement is fixed to the wire frame at the middle as shown in the figure. The set-up is **first balanced horizontally** on two knife-edges by adjusting the position of the rider  $R$ . The knife-edges are in contact with the wire frame so that a current can be passed through the frame by connecting an external current source to the knife-edges.

As shown in the figure a long straight wire  $PQ$  carrying a current  $I$  is now placed parallel to the wire segment  $CD$  at a distance  $h$  vertically below it.

Neglect the earth's magnetic field in answering the following questions.

- (a) Write down an expression for the magnetic flux density  $B$  at a point on  $CD$ , due to the current  $I$  through  $PQ$ .

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- (b) A current  $i$  is now made to flow through the wire frame in the direction shown in the diagram. Obtain an expression for the magnitude of the force  $F$  acting on  $CD$  due to  $B$  above, once the wire frame is **rebalanced horizontally** by adjusting rider  $R$ .

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- (c) On the diagram, indicate with an arrow, the direction along which the rider  $R$  has to be moved from its initial position, in order to rebalance the wire frame in part (b) above.

Briefly explain why you need to move the rider in the direction indicated in order to rebalance the wire frame.

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- (d) In part (b) above, if the rider had to be moved by a distance  $\Delta x$  from its initial position to rebalance the wire frame, obtain an expression for  $I$  in terms of  $m$ ,  $i$ ,  $h$ ,  $a$ ,  $b$ ,  $\Delta x$ ,  $\mu_0$  and  $g$ , where  $m$  is the mass of the rider.

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(e) This set-up can be used for measuring an unknown current  $I$  passing through  $PQ$ , by connecting  $PQ$  and the wire frame in series. Rewrite your expression in part (d) above for this situation.

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(f) The set-up in part (e) above can be used to check the calibration of an ammeter.

(i) How would you connect the ammeter to the set-up?

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(ii) Briefly state the calibration procedure.

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(g) The sensitivity of the current measurement carried out with the set-up mentioned in part (e) above can be increased by changing the magnitudes of  $h$ ,  $m$ ,  $a$  and  $b$ . By placing a  $\checkmark$  in the appropriate column, indicate how you would increase the sensitivity of the current measurement.

Parameter	By increasing the magnitude	By decreasing the magnitude
$h$		
$m$		
$a$		
$b$		

\* \*