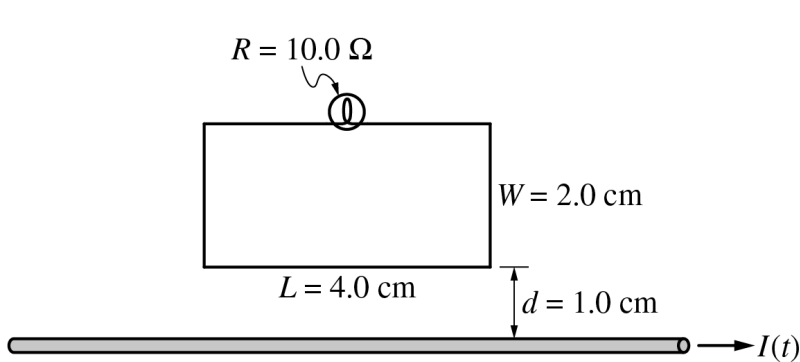




A lightbulb of resistance $R = 10.0 \, \Omega$ is connected to a rectangular loop of wire of negligible resistance near a very long current-carrying wire. The rectangular loop has a length $L = 4.0 \, \text{cm}$ and a width $W = 2.0 \, \text{cm}$ and is positioned so one of the longer sides of the loop is a distance $d = 1.0 \, \text{cm}$ above and parallel to the long wire, as shown. The current in the long wire is initially flowing to the right and is given by $I(t) = C - Dt$, where $C = 10.0 \, \text{A}$ and $D = 2.0 \, \text{A/s}$. At time $t = 5.0 \, \text{s}$, the current in the long wire is instantaneously zero as the current changes direction.

(a) What is the direction, if any, of the magnetic field produced by the induced current in the rectangular loop as the current in the long wire changes direction?

☐ Into the page ☐ Out of the page ☐ No direction, because the field is zero

Justify your answer.

(b) Calculate the magnetic flux through the loop due to only the long wire at time $t = 3.0 \, \text{s}$.

GO ON TO THE NEXT PAGE.

Continue your response to **QUESTION 3** on this page.

(c) Calculate the current through the lightbulb at time $t = 3.0 \, \text{s}$.

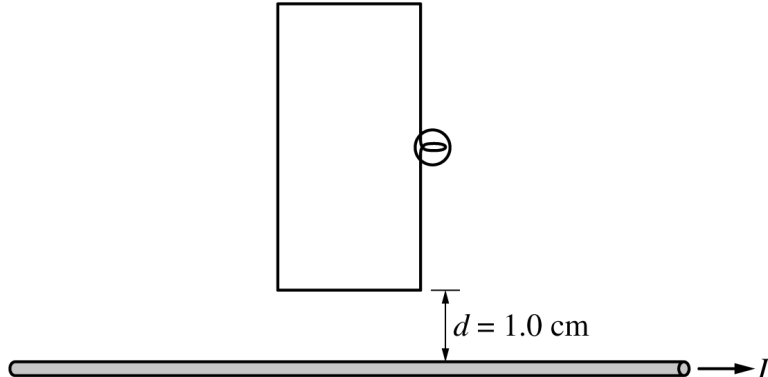
(d) A group of students attempts to experimentally verify whether the current through the lightbulb is consistent with the current calculation from part (c). The current in the rectangular loop is measured to be greater than the current calculated in part (c). Which of the following could explain this discrepancy? Select one answer.

- ☐ The students did not account for Earth's magnetic field.
☐ The rectangular loop is tilted and is not in the same plane as the wire.
☐ The resistance of the lightbulb is greater than the recorded value.
☐ The long side of the rectangular loop is shorter than the recorded value.
☐ The current in the long wire changes at a faster rate than expected.

Briefly justify your answer.

GO ON TO THE NEXT PAGE.

Continue your response to **QUESTION 3** on this page.



(e) Later, the same rectangular loop with lightbulb is rotated such that a short side of the loop is $1.0 \, \text{cm}$ above and parallel to the long current-carrying wire, as shown. The current in the wire is again initially flowing from left to right and given by $I(t) = C - Dt$, where $C = 10.0 \, \text{A}$ and $D = 2.0 \, \text{A/s}$. The current through the lightbulb in the loop's new orientation at time $t = 3.0 \, \text{s}$ is I_2 . Which of the following correctly relates the current I_2 to I_1 , the current through the lightbulb in part (c)?

☐ $I_2 < I_1$ ☐ $I_2 = I_1$ ☐ $I_2 > I_1$

Justify your answer.

GO ON TO THE NEXT PAGE.

STOP

END OF EXAM