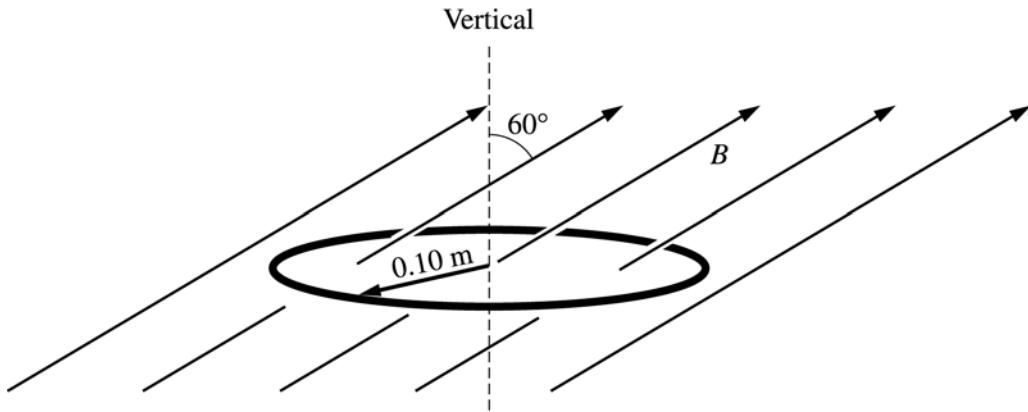


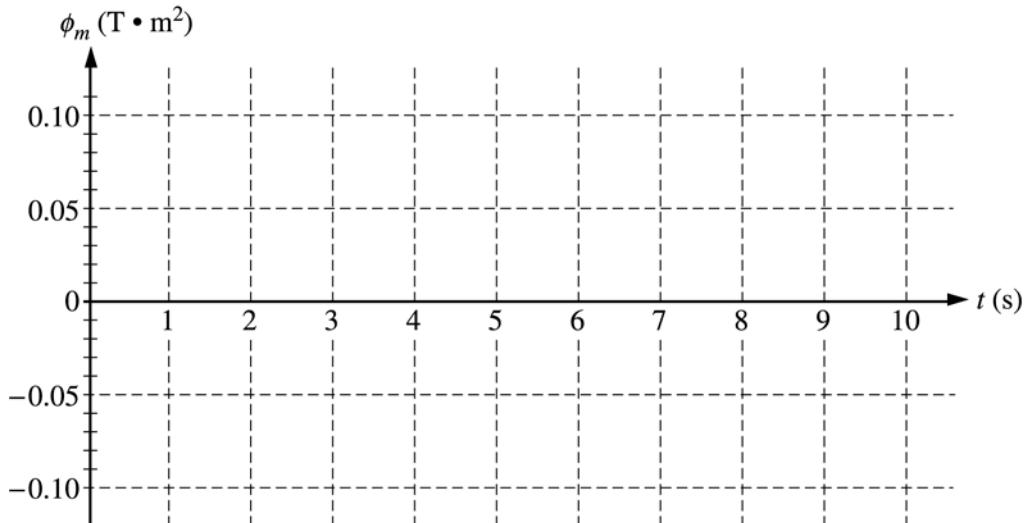
**2002 AP® PHYSICS C: ELECTRICITY AND MAGNETISM  
FREE-RESPONSE QUESTIONS**



E&M 3.

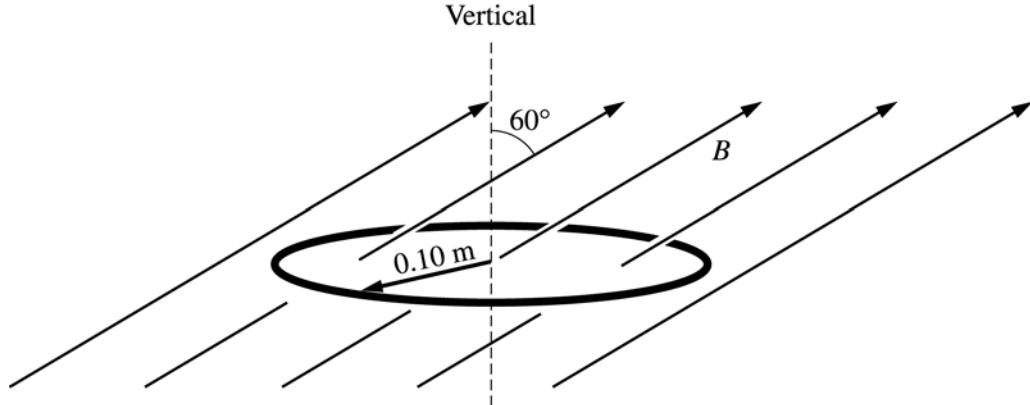
A circular wire loop with radius  $0.10\text{ m}$  and resistance  $50\ \Omega$  is suspended horizontally in a magnetic field of magnitude  $B$  directed upward at an angle of  $60^\circ$  with the vertical, as shown above. The magnitude of the field in teslas is given as a function of time  $t$  in seconds by the equation  $B = 4(1 - 0.2t)$ .

- Determine the magnetic flux  $\phi_m$  through the loop as a function of time.
- Graph the magnetic flux  $\phi_m$  as a function of time on the axes below.



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- (c) Determine the magnitude of the induced emf in the loop.
- (d)
- Determine the magnitude of the induced current in the loop.
  - Show the direction of the induced current on the following diagram.



- (e) Determine the energy dissipated in the loop from  $t = 0$  to  $t = 4\text{ s}$ .

**END OF SECTION II, ELECTRICITY AND MAGNETISM**

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2002 SCORING GUIDELINES**

**Question 3**

**15 points total**

**Distribution of points**

(a) 5 points

$$\phi_m = \int \mathbf{B} \cdot d\mathbf{A}$$

For a correct evaluation of the above expression

1 point

$$\phi_m = BA \cos \theta \text{ or } \phi_m = BA \sin \delta$$

For a correct determination of the area enclosed by the loop

1 point

$$A = \pi r^2 \text{ with } r = 0.10 \text{ m}$$

For a correct substitution of the angle

1 point

$$\theta = 60^\circ \text{ or } \delta = 30^\circ$$

For a correct substitution of the given equation for the magnetic field

1 point

$$B = 4(1 - 0.2t) \text{ T}$$

Making all the above substitutions

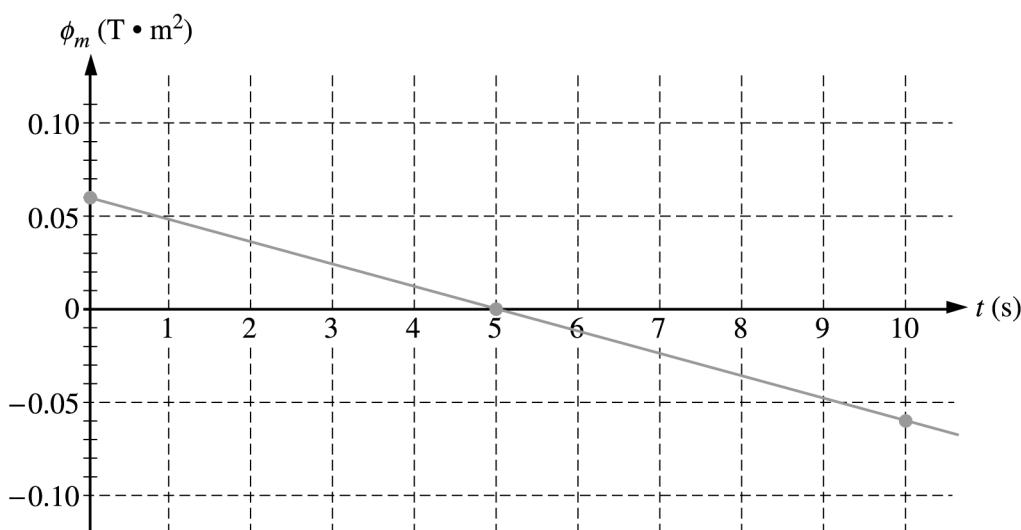
$$\phi_m = [4(1 - 0.2t) \text{ T}] \pi (0.10 \text{ m})^2 \cos 60^\circ$$

For a correct evaluation of the expression for the magnetic flux

1 point

$$\phi_m = (0.063)(1 - 0.2t) \text{ T} \cdot \text{m}^2 \text{ or weber}$$

(b) 2 points



For a correct  $x$  or  $y$  intercept (consistent with student's answer to part (a))

1 point

For a correct shape (consistent with student's answer to part (a))

1 point

For the correct expression for  $\phi_m$ , this means a straight line with the proper slope