AP® Physics C: Electricity & Magnetism
2002 Sample Student Responses

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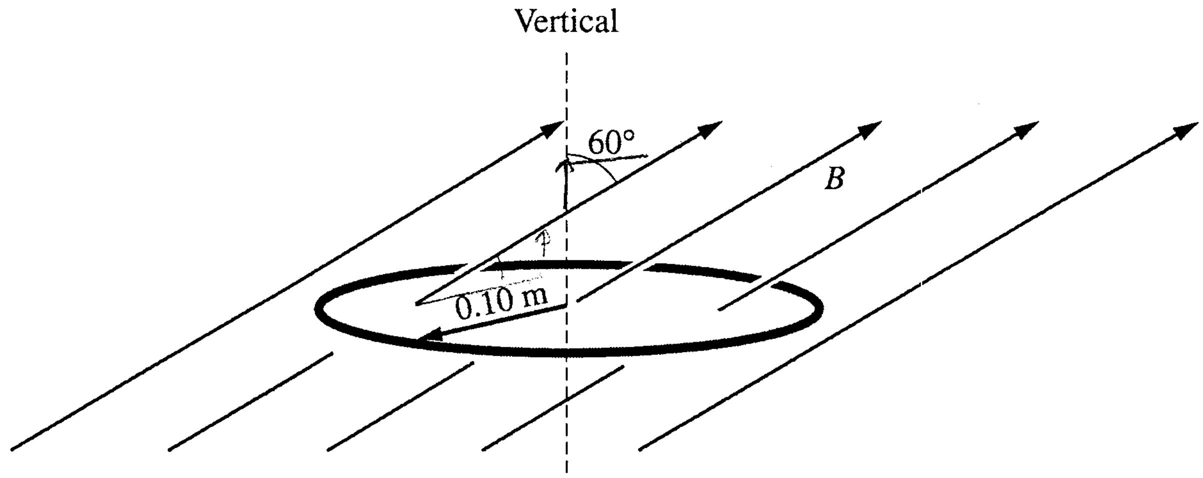


E&M 3.

A circular wire loop with radius 0.10 m and resistance 50 Ω is suspended horizontally in a magnetic field of magnitude B directed upward at an angle of 60° 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 $B = 4(1 - 0.2t)$.

(a) Determine the magnetic flux ϕ_m through the loop as a function of time.

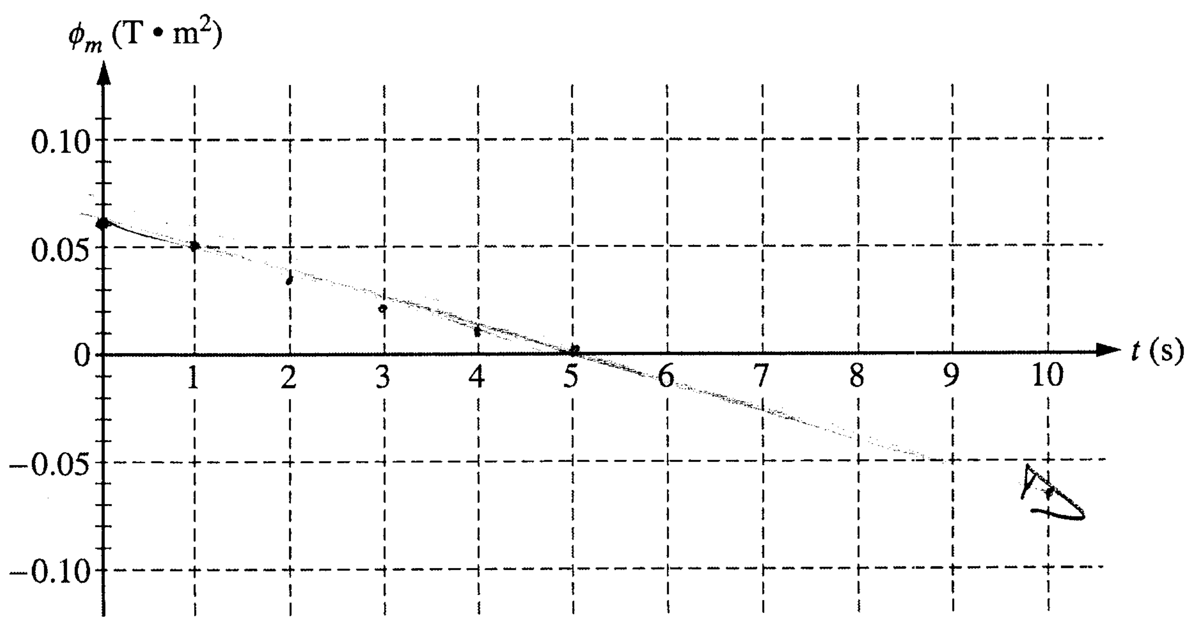
$A = \pi r^2$

$\Phi = BA\cos(\theta)$

$= 4(1-.2t)\cos(60)(\pi(.1)^2)$

$\Phi_B = .0628(1-.2t)$

(b) Graph the magnetic flux ϕ_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.

$$\mathcal{E} = -\frac{d\Phi}{dt} = \frac{-d(.0628(1-.2t))}{dt} = -(-.01256)$$

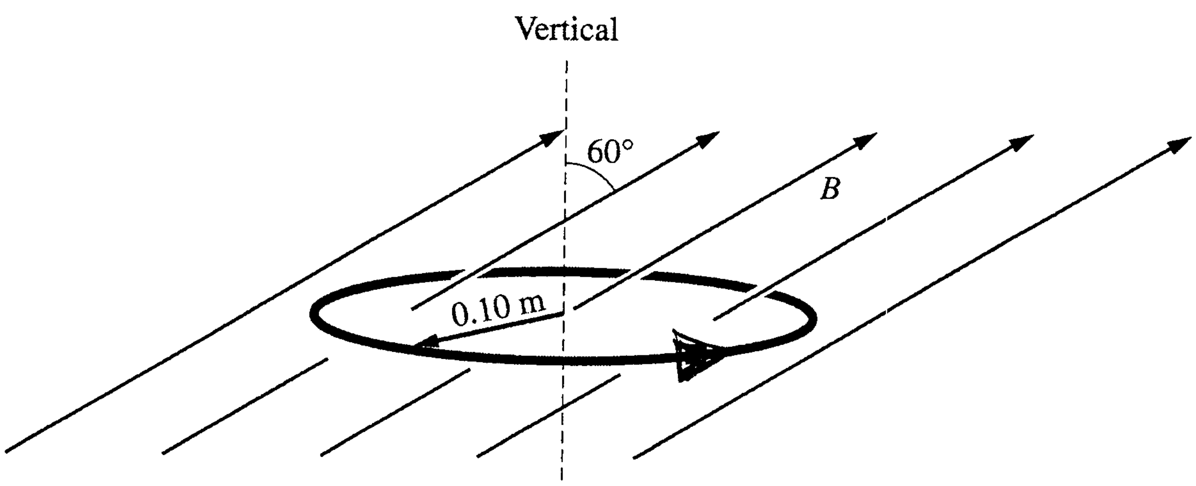
$$\mathcal{E} = \frac{d\Phi}{dt} = .01256\ V$$

(d) i. Determine the magnitude of the induced current in the loop.

$$V = IR$$

$$\frac{V}{R} = I = \frac{.01256}{50} = 2.512\times10^{-4}\ A$$

ii. Show the direction of the induced current on the following diagram.



(e) Determine the energy dissipated in the loop from $t = 0$ to $t = 4$ s.

$$P = I^2R$$

$$\int P\,dt = \text{ENERGY}$$

$$\int_0^4 I^2R\,dt = (2.512\times10^{-4})^2(50)\,t\Big|_0^4 = (3.155)(4)$$

$$E_{\text{dissipated}} = 1.262\times10^{-5}\ J$$

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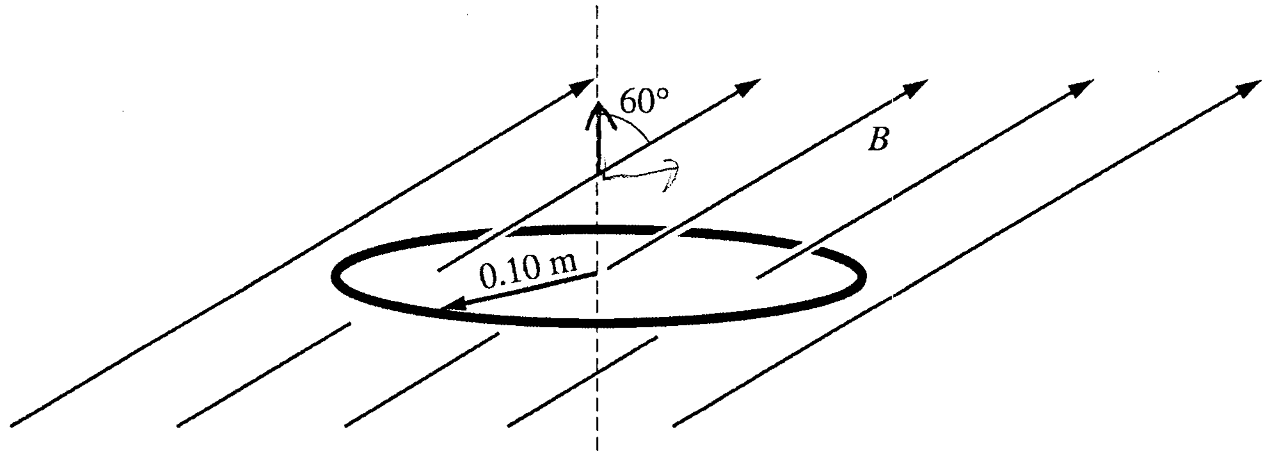


E&M 3.

A circular wire loop with radius 0.10 m and resistance 50 Ω is suspended horizontally in a magnetic field of magnitude B directed upward at an angle of 60° 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 $B = 4(1 - 0.2t)$.

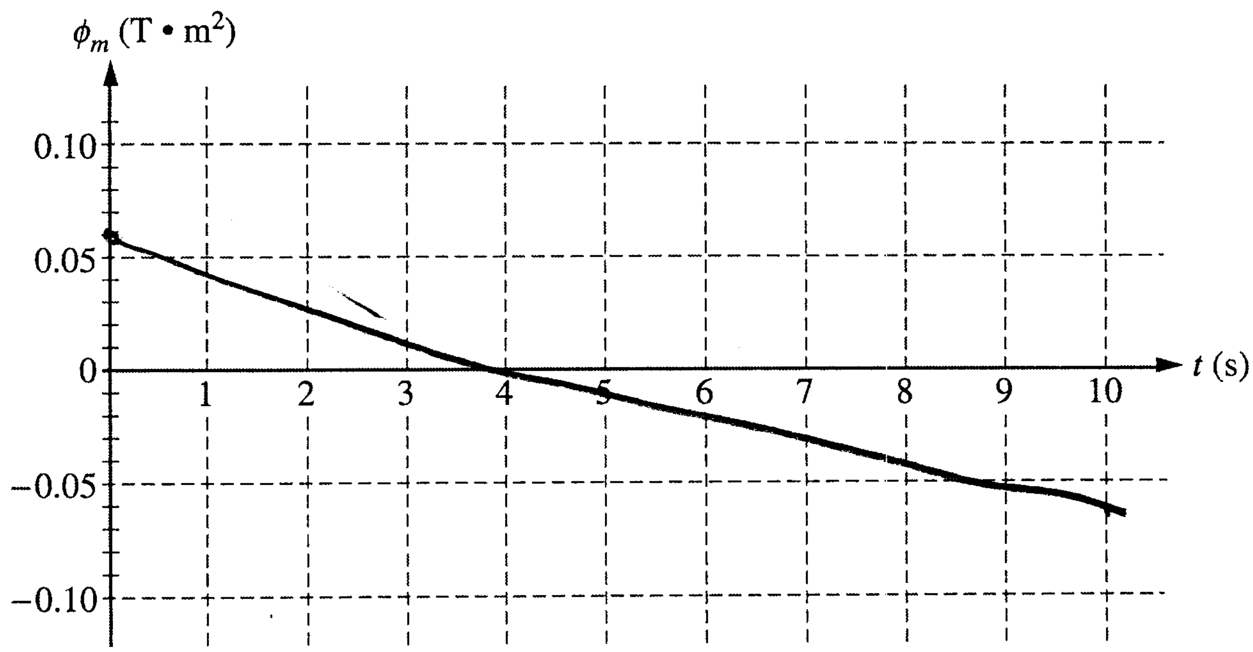
(a) Determine the magnetic flux ϕ_m through the loop as a function of time.

$\phi = \int B \cdot da = \int B\,da \cos 60 = \frac{1}{2}\int B \cdot da = \frac{1}{2} BA = \frac{1}{2} B \pi .1^2$

$\phi = (4(1-.2t)).0157$

$.068(1-.2t)$

(b) Graph the magnetic flux ϕ_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.

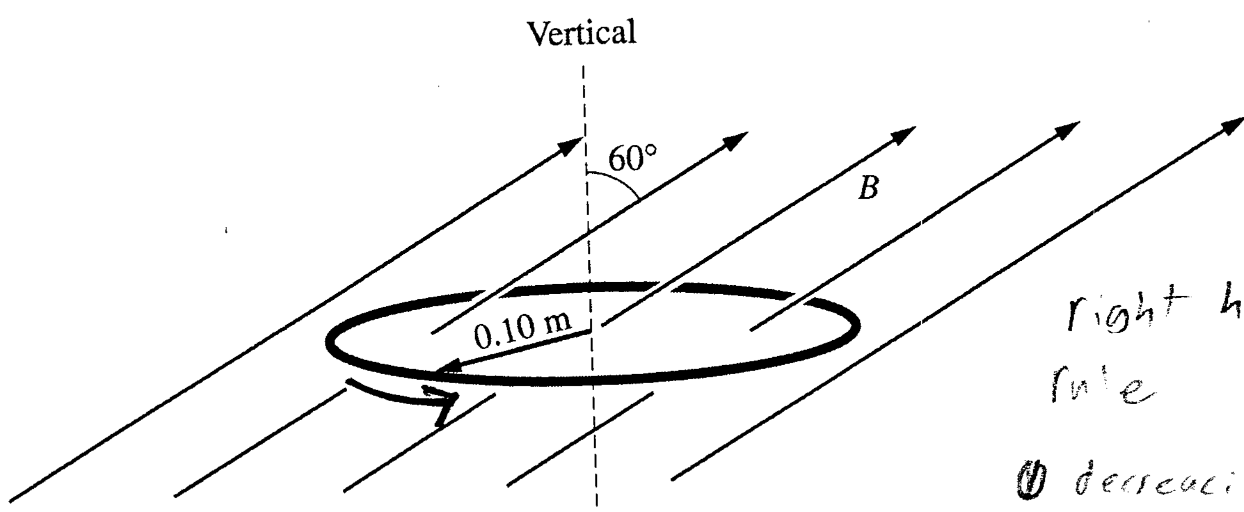
$$\mathcal{E} = \frac{d\phi}{dt} = \frac{d(.0628(1-.2t))}{dt}$$

$$= .0628 \cdot 2 = .01256$$

(d) i. Determine the magnitude of the induced current in the loop.

$$\frac{V}{R} = IR = \frac{.01256}{50} = 2.5 \times 10^{-4}$$

ii. Show the direction of the induced current on the following diagram.



right hand rule

ϕ decreasing

(e) Determine the energy dissipated in the loop from $t = 0$ to $t = 4$ s.

$$P = IV$$

$$= .01256 \cdot 2.5 \times 10^{-4} = 3.16 \times 10^{-6}$$

$P \cdot t$ = Energy dissipated $= 1.26 \times 10^{-5}$

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