Q- A circular loop of radius *a* = 20 cm and *N*= 168 turns is fixed in the *x*-*y* plane. A spatially uniform magnetic field with only a *z*-component covers the entire area of the loop. The plot at the right shows B_z measured in tesla versus time *t* measured in seconds. The +*z* direction is OUT of the screen.

(a) Calculate the *magnetic flux* through the loop in the *z*-direction at the times indicated below. In each case, specify the direction by giving a positive value for flux in the +*z* direction and a negative value for flux in the -*z* direction.

The flux through a loop of area A, in a magnetic field B and having number of turns N is given by

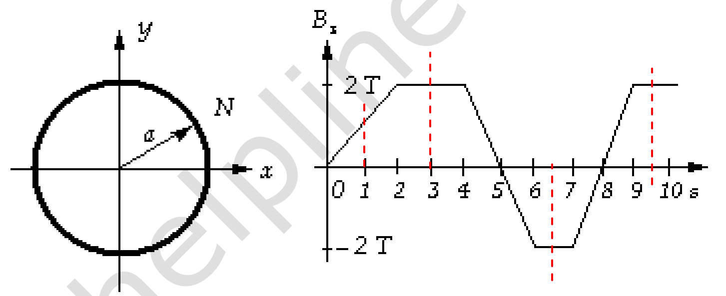
$$\phi = N*B*A \cos\theta$$

Where θ is the angle between area vector A and the field B.

Or $\phi = N*B*\pi a^2 \cos\theta$

Or $\phi = 168*B*3.14*0.2^2 \cos\theta$

Or $\phi = 21.1*B \cos\theta$



As the positive direction of the field and area both are the same (+z), θ = 0 and hence cos θ = 1 hence

$$\phi = 21.1*B$$

Substituting the values of the magnetic field from the graph we get

At t=1.0 s the field B = 1 T gives

$$\phi_1 = 21.1*1 = 21.1 \text{ T-m}^2$$

At t=3.0 s the field B = 2 T gives

$$\phi_2 = 21.1*2 = 42.2 \text{ T-m}^2$$

At t=5.0 s the field B = 0 T gives

$$\phi_3 = 0 \text{ T-m}^2$$

At t = 6.5 s the field B = - 2 T gives

$$\phi_4 = 21.1*(-2) = -42.2 \text{ T-m}^2$$

At t = 8 s the field B = 0 T gives

$$\phi_5 = 21.1*0 = 0 \text{ T-m}^2$$

At t = 9.5 s the field B = 2 T gives

$$\phi_6 = 21.1*2 = 42.2 \text{ T-m}^2$$

(b) Calculate the *induced EMF* (electromotive force) in the loop at the times specified below. In each case specify the sense of the EMF by giving a positive value for a counterclockwise EMF as viewed in the above figure; specify a clockwise sense by giving a negative value.

The induced EMF is given by the faraday's law as

$$E = - d\phi/dt = - N*A*(dB/dt) = - 21.1*(dB/dt)$$

The rate of change of field is given by the slope of the graph

In first two second the field increases from 0 to 2T by 2T in 2 sec and hence the slope is 2/2 = 1 T/s and hence the induced EMF will be

$$E_1 = - 21.1*1 = -21.1 \text{ V}$$

The direction is in accordance to the Lenz law

At t = 3.0 s the graph is parallel to t axis means B is constant and hence dB/dt = 0 so induced EMF is also zero.

$$E_2 = 0$$

From 4 to 6 s the field changes uniformly from 2T to -2T in 2 sec hence dB/dt = - 2 T/s hence at t = 5 s

$$E_3 = -21.1*(-2) = +42.2 \text{ V}$$

At t = 6.5 s the graph is parallel to t axis means B is constant and hence dB/dt = 0 so induced EMF is also zero

$$E_4 = 0$$

From 7 to 9 s the field changes uniformly from -2T to 2T in 2 sec hence dB/dt = 2 T/s hence

$$E_5 = -21.1*2 = - 42.2 \text{ V}$$

At t = 9.5 s the graph is parallel to t axis means B is constant and hence dB/dt = 0 so induced EMF is also zero

$$E_6 = 0$$