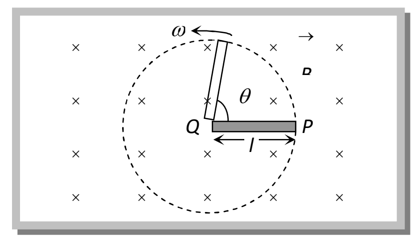
Motional EMI Due to Rotational Motion.

(1) Conducting rod

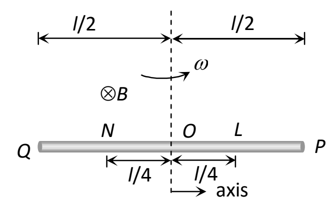
A conducting rod of length l whose one end is fixed, is rotated about the axis passing through it's fixed end and perpendicular to it's length with constant angular velocity ω. Magnetic field (B) is perpendicular to the plane of the paper.



emf induces across the ends of the rod $e = \frac{1}{2}Bl^2\omega = Bl^2\pi\nu = \frac{Bl^2\pi}{T}$

whereν = frequency (revolution per sec) and T = Time period.

Note: If above metallic rod rotated about its axis of rotation, then induced potential difference between any pair of identical located points of rod, is always zero.



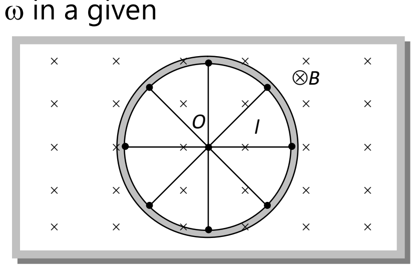
It is clear parts OP and OQ are identical hence

$e_{OP} = e_{OQ}$ i.e. $e_{PQ} = 0$

Similarly $e_{LN} = 0\,(V_L = V_N)$

(2) Cycle wheel

A conducting wheel each spoke of length l is rotating with angular velocity ω in a given magnetic field as shown below in fig.



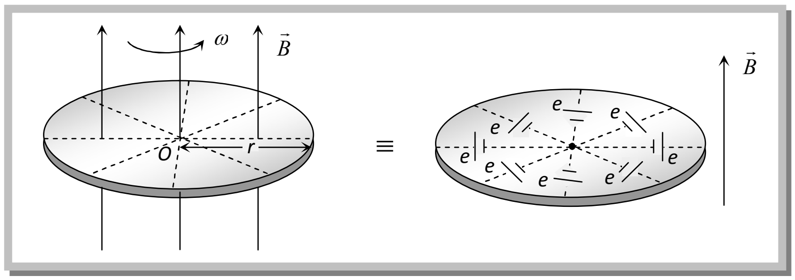
Due to flux cutting each metal spoke becomes identical cell of emf e (say), all such identical cells connected in parallel fashion $e_{net} = e$ (emf of single cell). Let N be the number of spokes hence $e_{net} = \frac{1}{2}Bwl^2; \omega = 2\pi\nu$

Here $e_{net} \propto N^o$ i.e. total emf does not depends on number of spokes 'N'.

Note: Here magnetic field (may be component of Earth's magnetic field) sometimes, depends on plane of motion of wheel. If wheel rotates in horizontal plane, then B = BV used; If wheel rotates in vertical plane, then B = BH used (BH-horizontal component of earth's magnetic field while BV-vertical component)

(3) Faraday copper disc generator

During rotational motion of disc, it cuts away magnetic field lines.



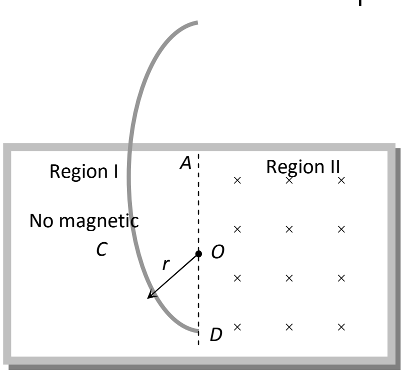
A metal disc can be assumed to made of uncountable radial conductors when metal disc rotates in transverse magnetic field these radial conductors cuts away magnetic field lines and because of this flux cutting all becomes identical cells each of emf 'e' where $e = \frac{1}{2} B\omega r^2$, as shown in following fig. and periphery of disc becomes equipotential.

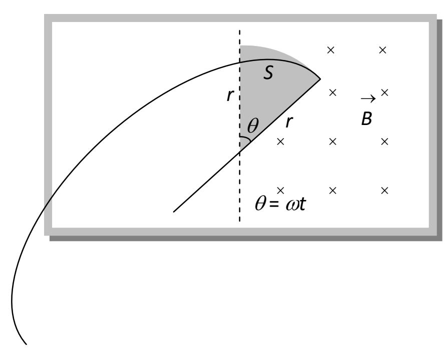
All identical cells connected in parallel fashion, So net emf for disc enet = $e = \frac{1}{2} B\omega r^2 = B(\pi r^2)\nu$

Note: If a galvanometer is connected between two peripheral points or diametrical opposite ends it's reading will be zero.

(4) Semicircular conducting loop

For the given figure a semi-circular conducting loop (ACD) of radius 'r' with centre at O, the plane of loop being in the plane of paper. The loop is now made to rotate with a constant angular velocity ω, about an axis passing through O and perpendicular to the plane of paper. The effective resistance of the loop is R.





In time t the area swept by the loop in the field i.e. region II $A = \frac{1}{2} r(r\theta) = \frac{1}{2} r^2 \omega t$; $\frac{dA}{dt} = \frac{r^2 \omega}{2}$

Flux link with the rotating loop at time t $\phi = BA$

Hence induced emf in the loop in magnitude $|e| = \frac{d\phi}{dt} = B\frac{dA}{dt} = \frac{B\omega r^2}{2}$ and induced current $i = \frac{|e|}{R} = \frac{B\omega r^2}{2R}$