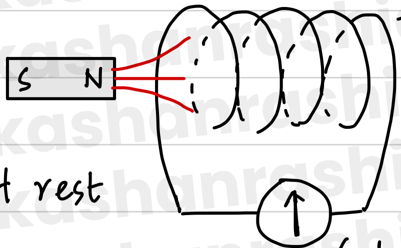
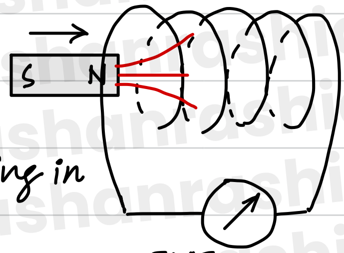
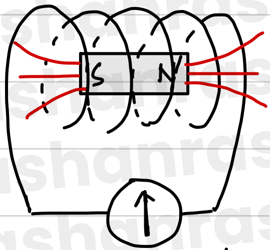
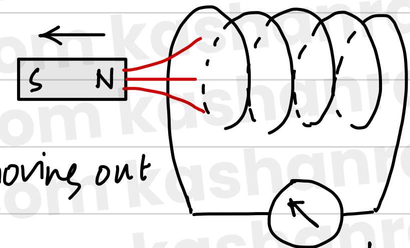
# ELECTROMAGNETIC INDUCTION



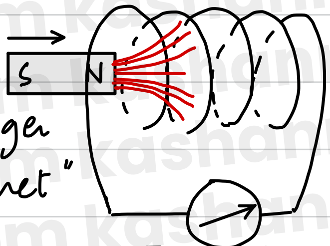



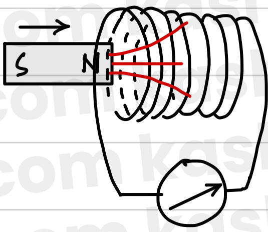



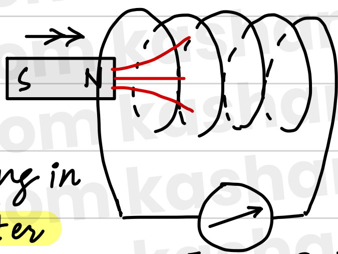




" To induce EMF a change in interaction of magnetic field with the conductor (coil of wire) is needed. "

For that the magnet or the coil must move relative to the other.



## Faraday's Law of Electromagnetic Induction

The EMF induced in the conductor is directly proportional to the rate of change of magnetic flux linkage.

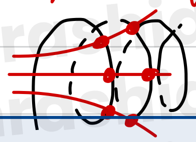
↓

interaction of magnetic field with the conductor / coil of wire.

$$V \propto \frac{N\Delta\phi}{\Delta t}$$

$$V = \frac{N\Delta\phi}{\Delta t}$$

- $V$ → induced EMF
- $N$ → no. of turns
- $\Delta\phi$ → change in flux
- $\Delta t$ → time interval



**magnetic flux linkage = $N\phi$**

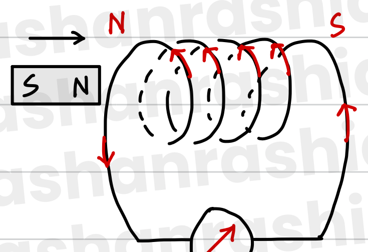
N: no. of turns of coil
$\phi$: magnetic flux

**magnetic flux linkage = $NBA$**

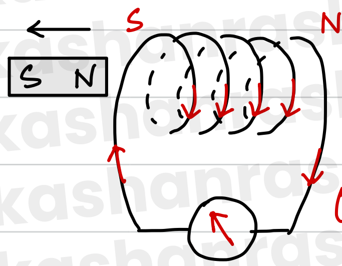
B: magnetic flux density
A: cross-sectional area

## Lenz's Law

The EMF induced in the conductor is such that it opposes the change which produces it




insert : repel
(Like poles)

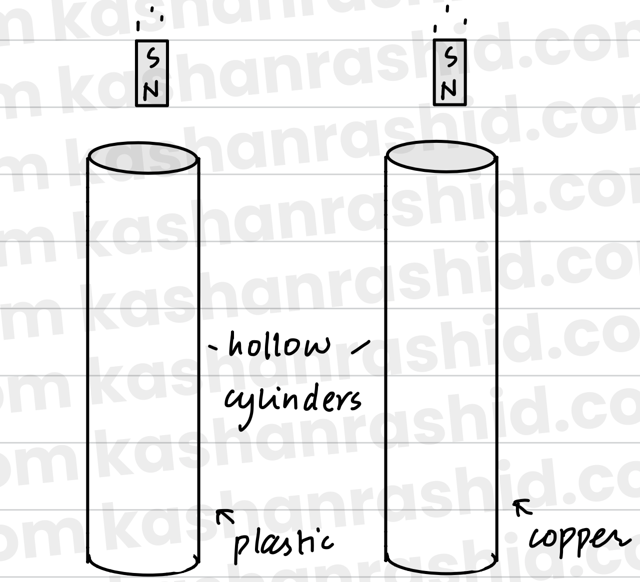



pull out : attract
(unlike poles)

"Opposition is bound to happen as it causes the magnet to lose it kinetic energy and create electrical energy."

$$V = \frac{N\Delta\phi}{\Delta t} \qquad V = -\frac{N\Delta\phi}{\Delta t}$$

without Lenz's Law — with Lenz's Law

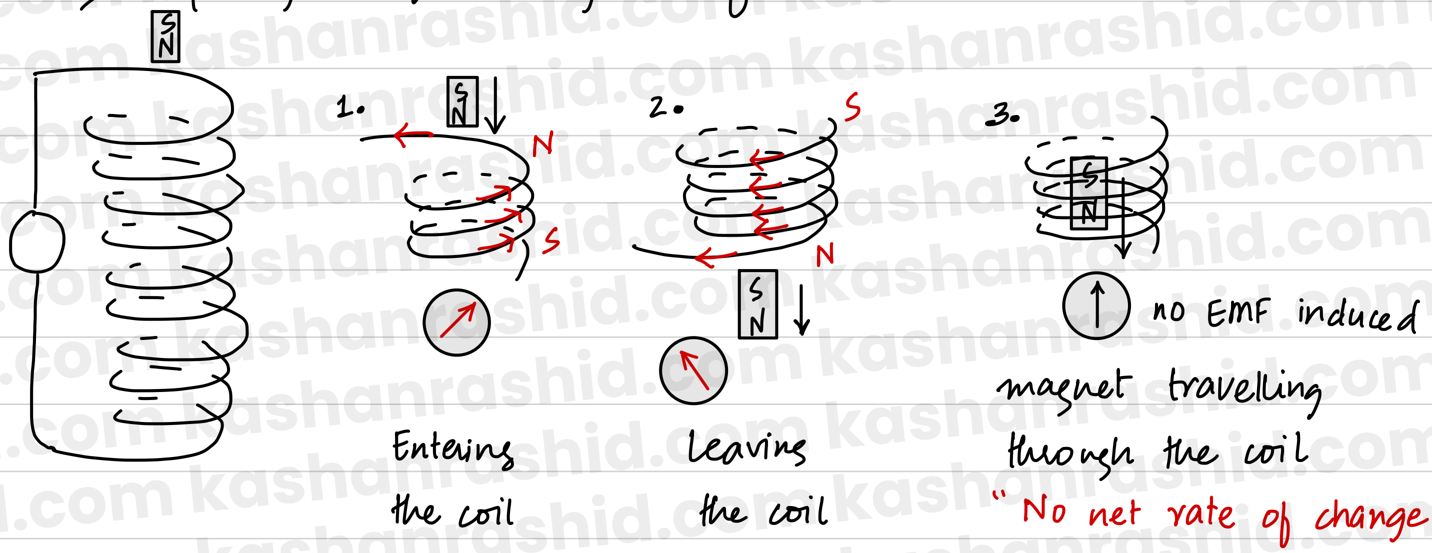



- Magnet falls slower in a copper tube but falls at normal acceleration in a plastic tube.

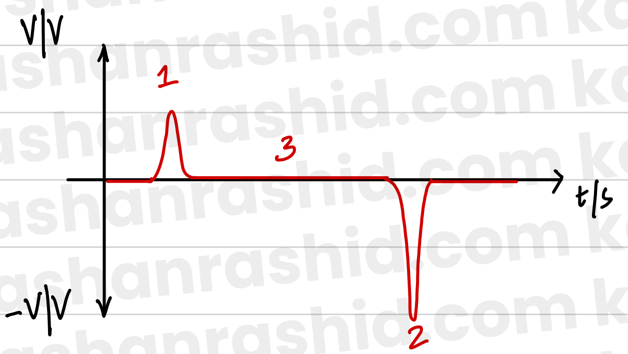
→ While moving in a copper Tube, the current induced in copper will oppose the motion of magnet (according to Lenz's Law) and slow its speed down.

→ No current induced in plastic tube so effect.

Magnet falling through a long coil of wire




"No net rate of change of magnetic flux linkage."



$$V = \frac{N\Delta\Phi}{\Delta t}$$

## Data based

✓ No. of turns (N)

✓ Magnetic flux density (B)

↳ or an equation to find B

✓ Area

↳ or diameter ($A = \pi r^2$ | $A = \frac{\pi d^2}{4}$)

✓ Time

- $\phi = B \times A$
- magnetic flux linkage $= N\phi$ $= NBA$

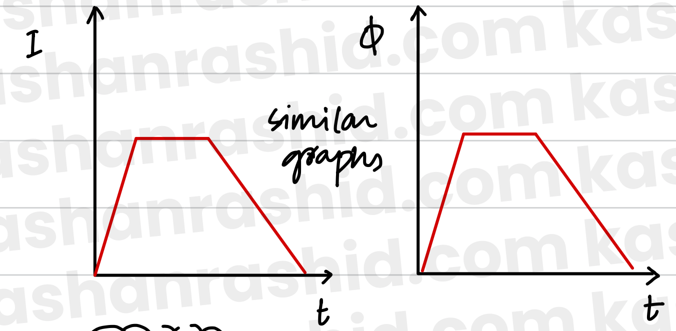
$V = \frac{N\Delta\phi}{\Delta t}$

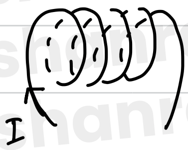
$V = \frac{N(\phi_2 - \phi_1)}{t}$ — $\phi_2$ → final flux, $\phi_1$ → initial flux, $t$ → time taken

$V = \frac{N\phi_2 - N\phi_1}{t}$ → flux linkage

(mostly used form)

## Graph based




current supplied to a coil to create a magnetic field

flux created around the coil which is creating the magnetic field.

Draw a V-t graph using the graphs above.

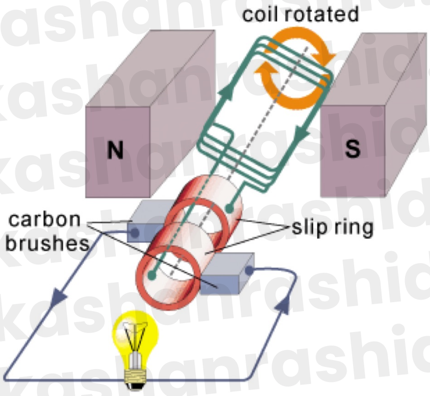
* induced EMF ∝ gradient of $\phi$-t or * I-t graph

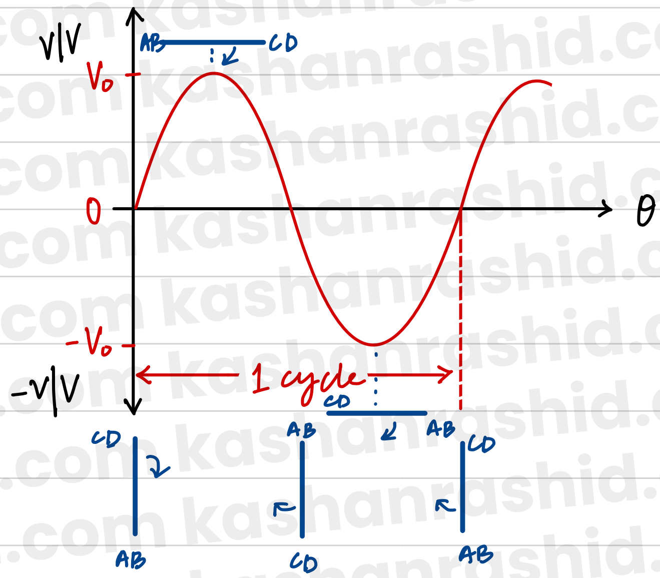
* As the magnet falls through the copper tube, there is a rate of change of magnetic flux linkage. The induced current in the copper tube creates such a magnetic field which opposes the motion of magnet. This decreases the speed of the magnet and it falls slowly.

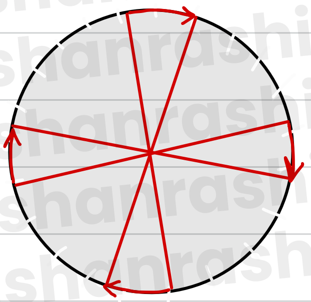
# ALTERNATING CURRENT

Graph of Alternating current    Root-Mean-Square Voltage & Current

Rectification i.e. AC to DC



→ When coil crosses HORIZONTAL position, MAX emf induced.

→ When coil crosses VERTICAL position, MIN EMF induced.

$y = A\sin Bx + C$

- B: no. of cycles in 360° (1)
- A: amplitude ($V_0$)
- C: y-int (0)

→ $V = V_0 \sin(1)\theta + 0$

$V = V_0 \sin\theta$

as $\theta = \omega t$, then

$$\boxed{V = V_0 \sin\omega t}$$

similarly for current

$$\boxed{I = I_0 \sin\omega t}$$

e.g. $V = 110\sin 30\pi t$

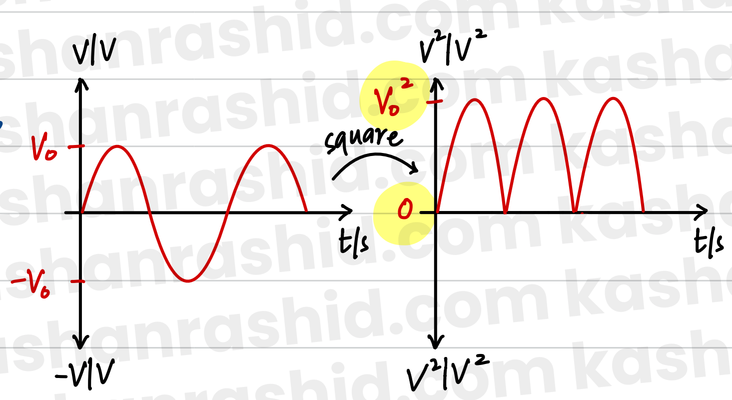
$V = V_0 \sin\omega t$

- $V_0 = 110\,V$
- $\omega = 30\pi$
- $2\pi f = 30\pi$

  $f = 15\,Hz$
- $f = \frac{1}{T}$ so $T = \frac{1}{15}$

## Root-Mean-Square Voltage/Current

A value of direct voltage corresponding to an alternating voltage that gives the same mean power output as an alternating voltage would.




A value of direct current corresponding to an alternating current that gives the same mean power output as an alternating current would.

$$V_{ms} = \frac{V_0^2 + 0}{2} \qquad V_{ms} = \frac{V_0^2}{2}$$

$$\boxed{V_{rms} = \frac{V_0}{\sqrt{2}}}$$

$$\boxed{I_{rms} = \frac{I_0}{\sqrt{2}}}$$

e.g. $V_0 = 240\text{ V}$

$$V_{rms} = \frac{240}{\sqrt{2}} \qquad V_{rms} = 170\text{ V}$$

Simple (arithmatic) mean of alternating voltage/current is zero.

$R = \frac{V}{I}$ either $R = \frac{V_0}{I_0}$ ✓ or $R = \frac{V_{rms}}{I_{rms}}$ ✓

$P = IV$

- $P = I^2R$
- $P = \frac{V^2}{R}$

if mean power

$P_{mean} = I_{rms} V_{rms}$

if max power

$P_{max} = I_0 V_0$

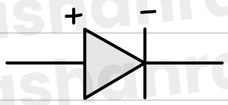
$$P_{mean} = I_{rms} \times V_{rms}$$

$$P_{mean} = \frac{I_0}{\sqrt{2}} \times \frac{V_0}{\sqrt{2}}$$

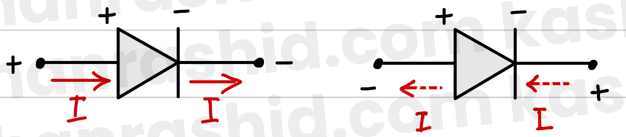
$$\boxed{P_{mean} = \frac{P_{max}}{2}}$$

## Rectification

A process of converting AC to DC.

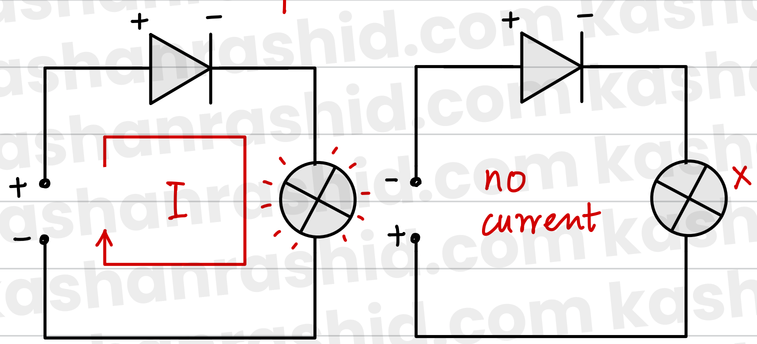


*A diode is used for the rectification process.



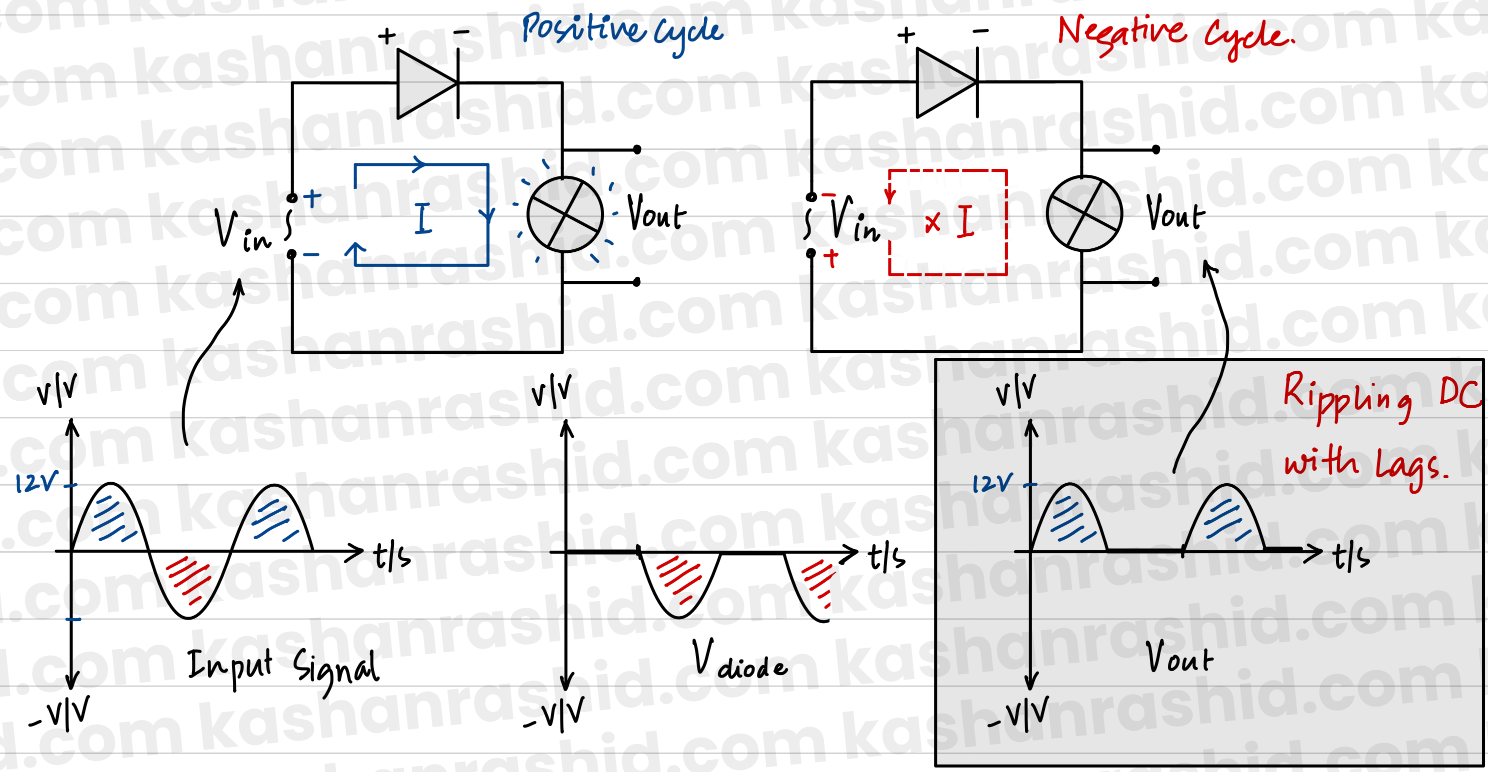

| Forward Biased | Reverse Biased |
|---|---|
| (++/--) | (+-/-+) |
| conduction occurs | No conduction |
| ($R = 0\Omega$) | ($R = \infty\Omega$) |

for ideal diodes

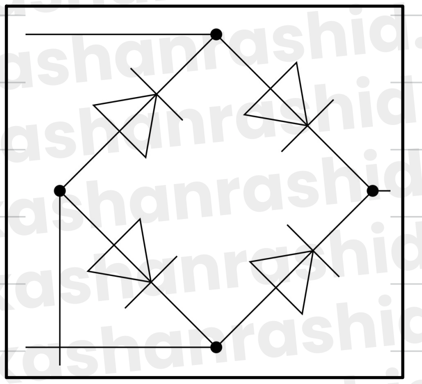



## Half Wave Rectification

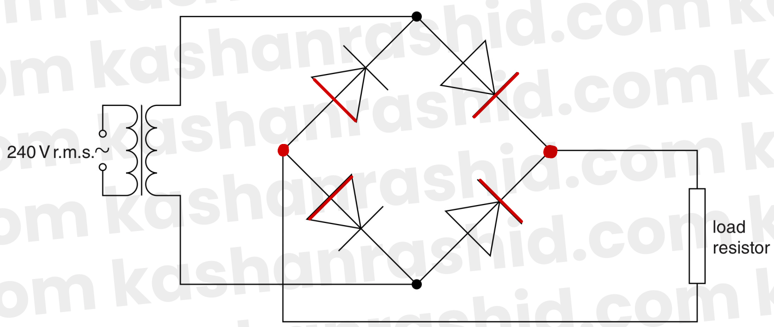
Half of the input signal is obtained at the output.



# Full Wave Rectification

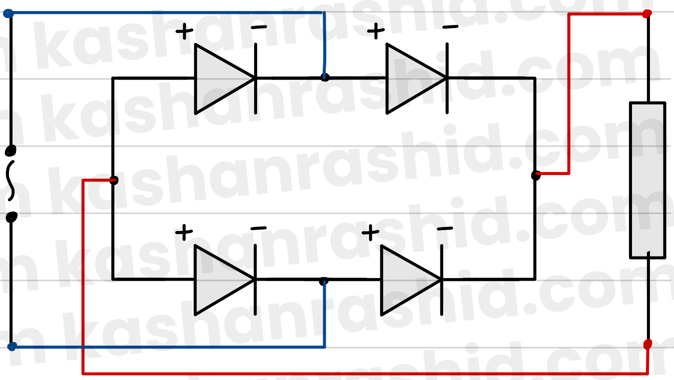


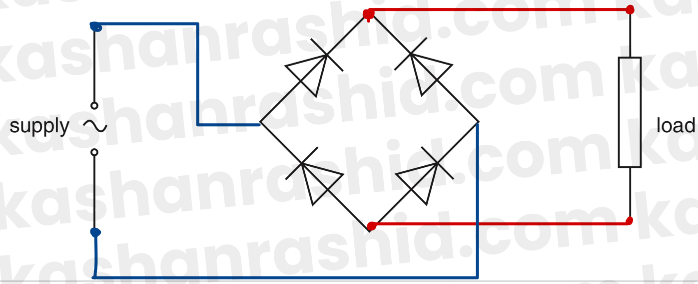
Bridge Rectifier



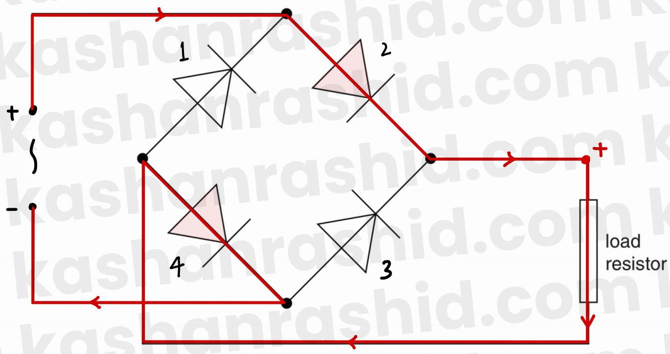

Like terminal junctions : Output

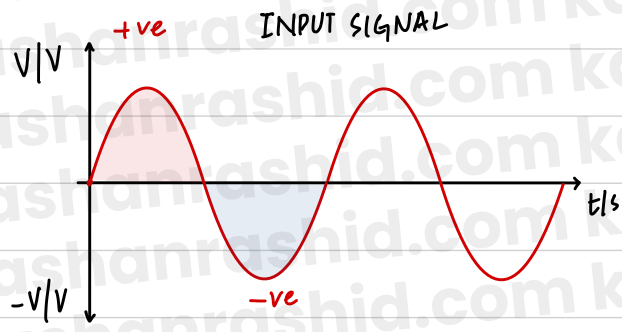
Unlike terminal junctions : Input



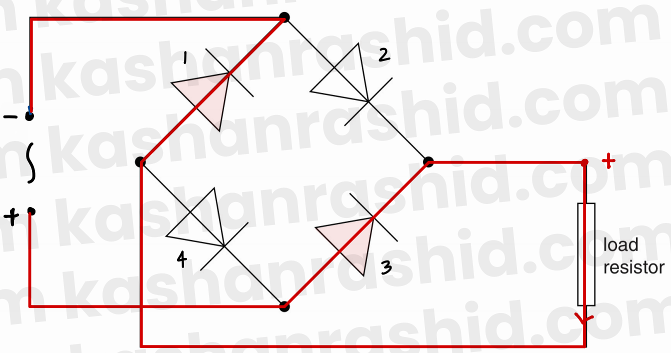



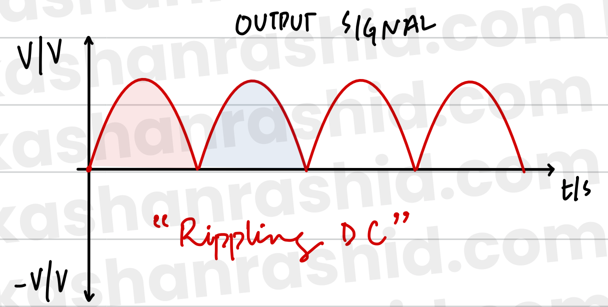

Postive Half Cycle



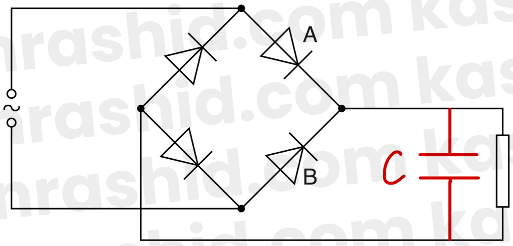

Negative Half Cycle

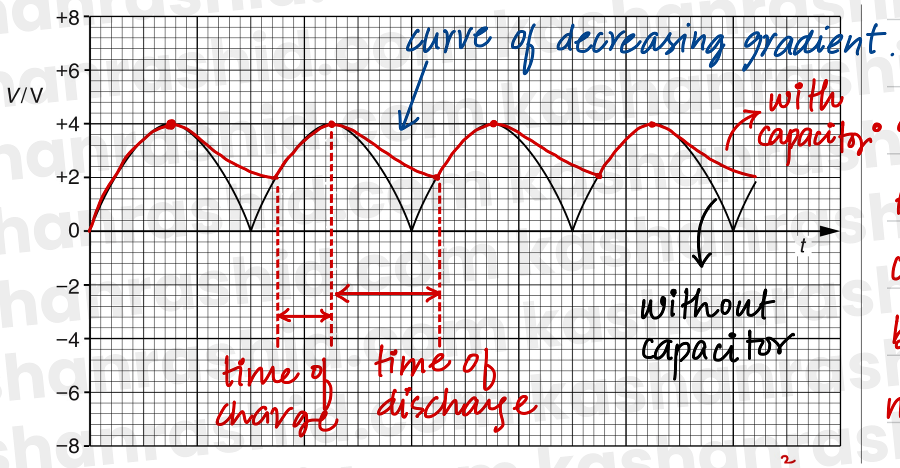


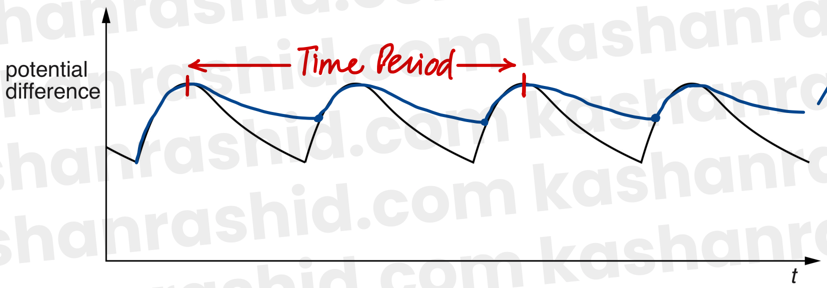
## Smoothing

A method of decreasing the magnitude of ripple / drop at the output voltage by adding a capacitor in parallel to the resistor.




- Smoothing increases the mean power output across resistor because the average / mean voltage increases




Using a larger capacitor of more capacitance.

More Smoothing!

Magnitude of ripple decreases