

# Subject Name Solutions

4311101 – Summer 2024

Semester 1 Study Material

*Detailed Solutions and Explanations*

## Question 1(a) [3 marks]

Define EMF, electric current and power. Also write their units.

### Solution

Term	Definition	Unit
EMF (Electromotive Force)	The energy supplied by a source per unit charge	Volt (V)
Electric Current	The rate of flow of electric charge	Ampere (A)
Power	The rate at which electrical energy is transferred	Watt (W)

### Mnemonic

“EVA” - EMF in Volts, Current in Amperes, Power in Watts

## Question 1(b) [4 marks]

Three resistors having resistances of  $1000 \Omega$ ,  $2000 \Omega$  and  $3000 \Omega$  respectively are connected in series. Find the equivalent resistance of this series connection. Now these three resistors are connected in parallel. Find the equivalent resistance of this parallel connection.

### Solution

#### For Series Connection:

$$R_{eq} = R_1 + R_2 + R_3$$

$$R_{eq} = 1000 \Omega + 2000 \Omega + 3000 \Omega$$

$$R_{eq} = 6000 \Omega$$

#### For Parallel Connection:

$$\frac{1}{R_{eq}} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$$

$$\frac{1}{R_{eq}} = \frac{1}{1000} + \frac{1}{2000} + \frac{1}{3000}$$

$$\frac{1}{R_{eq}} = 0.001 + 0.0005 + 0.00033$$

$$\frac{1}{R_{eq}} = 0.00183$$

$$R_{eq} = 545.45 \Omega$$

#### Diagram:

#### Mermaid Diagram (Code)

```
{Shaded}
{Highlighting} []
graph LR
    A[Input] --> B[1000 Ω]
    B --> C[2000 Ω]
    C --> D[3000 Ω]
    D --> E[Output]

    F[Input] --> G[1000 Ω]
    G --> H[Output]
    F --> I[2000 Ω]
    I --> H
    F --> J[3000 Ω]
    J --> H

{Highlighting}
{Shaded}
```

## Mnemonic

“Series Sum, Parallel Product/Sum” - In series add directly, in parallel take reciprocal sum

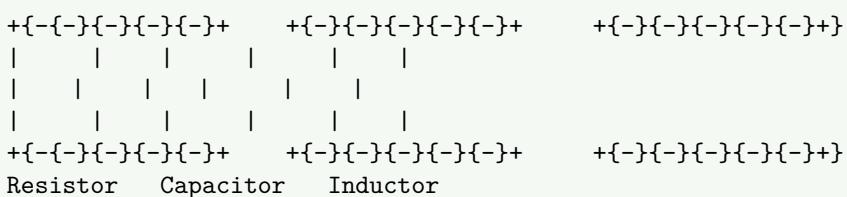
### Question 1(c) [7 marks]

Write the definition of Resistor, Capacitor and Inductor. Draw their symbols and write their units. Also write the use of each device in electrical circuit.

#### Solution

Component	Definition	Symbol	Unit	Use in Circuit
<b>Resistor</b>	A component that opposes the flow of electric current		Ohm ( $\Omega$ )	Limits current, divides voltage, generates heat
<b>Capacitor</b>	A component that stores electric charge		Farad (F)	Blocks DC, passes AC, energy storage, filtering
<b>Inductor</b>	A component that stores energy in magnetic field	$\otimes \otimes \otimes$	Henry (H)	Blocks AC, passes DC, energy storage, filtering

#### Diagram:



## Mnemonic

“RCI” - Resistor Controls current, Capacitor stores charge, Inductor stores magnetic energy

### Question 1(c OR) [7 marks]

State Ohm's law and write the equation of Ohm's law with circuit diagram. Write applications of Ohm's law. Also write the limitation of Ohm's law.

#### Solution

**Ohm's Law:** The current flowing through a conductor is directly proportional to the voltage across it and inversely proportional to its resistance.

**Equation:**  $V = I \times R$

**Circuit Diagram:**

#### Mermaid Diagram (Code)

```
{Shaded}  
{Highlighting} []  
graph LR  
    A[Voltage Source V] --> B[Resistor R]  
    B --> C[Current I]  
    C --> A  
{Highlighting}  
{Shaded}
```

#### Applications of Ohm's Law:

- Calculating current, voltage, or resistance in circuits
- Designing electrical and electronic circuits

- Power calculations ( $P = V \times I = I^2 \times R = V^2/R$ )
  - Circuit analysis using voltage divider and current divider
- Limitations of Ohm's Law:**
- Not applicable for non-linear devices (diodes, transistors)
  - Not valid for high-frequency AC circuits
  - Not valid for non-metallic conductors
  - Does not apply during transient conditions

### Mnemonic

“VIR” - Voltage equals current times resistance

### Question 2(a) [3 marks]

Explain the generation of alternating EMF with the help of necessary diagram and equation.

### Solution

Alternating EMF is generated when a conductor rotates in a magnetic field.

**Equation:**  $e = E_0 \sin(t) = E_0 \sin(2\pi ft)$

Where:

- $e$  = instantaneous EMF
- $E_0$  = maximum EMF
- $\omega$  = angular velocity ( $2\pi f$ )
- $f$  = frequency
- $t$  = time

**Diagram:**

Mermaid Diagram (Code)

```
{Shaded}
{Highlighting} []
graph LR
    A[Magnetic Field] --> B[Rotating Coil]
    B --> C[Slip Rings]
    C --> D[Brushes]
    D --> E[AC Output]
{Highlighting}
{Shaded}
```

### Mnemonic

“RCBS” - Rotation of Coil in magnetic field produces sinusoidal EMF

### Question 2(b) [4 marks]

Explain the behavior of pure capacitor with AC supply with necessary circuit diagram and equation.

### Solution

#### Behavior of Pure Capacitor with AC:

- Current leads voltage by  $90^\circ$  in a pure capacitor
- Capacitive reactance ( $X_C = 1/(2\pi fC)$ )
- As frequency increases, reactance decreases
- Stores energy in electric field during charging

#### Circuit and Waveform:



**Equation:**  $I = C \times dV/dt$

## Mnemonic

“CIVIC” - Capacitor’s current  $I_s$  ahead of Voltage by  $90^\circ$  *In Circuit*

### Question 2(c) [7 marks]

An AC voltage is expressed as  $300 \sin(628t)$  V. Find (i) Amplitude (ii) Frequency (iii) Time period (iv) Average value (v) RMS Value (vi) Form Factor and (vii) Peak Factor for this AC voltage.

## Solution

$$\text{Given: } v = 300 \sin(628t) \text{ V}$$

Parameter	Formula	Calculation	Result
<b>Amplitude</b>	$V_0$	300 V	300 V
<b>Angular Frequency</b>		628 rad/s	628 rad/s
<b>Frequency</b>	$f = \omega / 2\pi$	$628/2\pi = 628/6.28$	100 Hz
<b>Time Period</b>	$T = 1/f$	$1/100$	0.01 s
<b>Average Value</b>	$V_{avg} = 2V_0 / \pi$	$2 \times 300 / \pi = 600/3.14$	191 V
<b>RMS Value</b>	$V_{rms} = V_0 / \sqrt{2}$	$300 / \sqrt{2} = 300/1.414$	212.16 V
<b>Form Factor</b>	$FF = V_{rms}/V_{avg}$	$212.16/191$	1.11
<b>Peak Factor</b>	$PF = V_0/V_{rms}$	$300/212.16$	1.414

## Mnemonic

“FART FAFP” - Frequency is Angular frequency divided by 2 , RMS is peak divided by root 2, Time period is  $1/f$ , Form factor is 1.11, Average is  $2V_m/$ , Peak factor is 1.414

**Question 2(a OR) [3 marks]**

**Explain the generation of 3-phase alternating EMF.**

## Solution

3-phase alternating EMF is generated using three separate coils placed  $120^\circ$  apart in a magnetic field.

### **Key Points:**

- Three identical coils are placed  $120^\circ$  apart
  - Each coil produces sinusoidal EMF
  - Phases are labeled as R, Y, and B (or U, V, W)
  - Phase difference between any two phases is  $120^\circ$

• Phase Diagram:

### Mermaid Diagram (Code)

```
{Shaded}  
{Highlighting} []  
graph LR  
    A[Rotating Magnet] --> B[Three Coils 120° Apart]  
    B --> C[Three Phase Output]  
    D[Time] --> E[Three Phase Waveforms]  
{Highlighting}  
{Shaded}
```

### Mnemonic

“THREE” - Three coils Have 120° Rotating EMF Each

## Question 2(b OR) [4 marks]

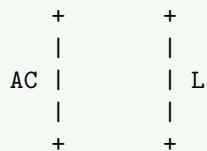
Explain the behavior of pure inductor with AC supply with necessary circuit diagram and equation.

### Solution

#### Behavior of Pure Inductor with AC:

- Current lags voltage by 90° in a pure inductor
- Inductive reactance ( $X_L$ ) =  $2\pi fL$
- As frequency increases, reactance increases
- Stores energy in magnetic field

#### Circuit and Waveform:



#### Voltage

A waveform diagram illustrating the voltage and current in a pure inductor. The vertical axis is labeled 'V' and the horizontal axis is labeled 'I'. The voltage waveform is a sine wave starting at zero. The current waveform is a sine wave starting at its peak value, indicating a 90° phase lag between voltage and current.

$$\text{Equation: } V = L \times dI/dt$$

### Mnemonic

“VLIC” - Voltage Leads current by 90° In inductor Circuit

## Question 2(c OR) [7 marks]

Define phase voltage, line voltage, phase current and line current for 3-phase AC. (i) Calculate the line voltage for star (Y) connection if the phase voltage is 100V. Also find the line current for star (Y) connection if the phase current is 5A (ii) Calculate the line voltage for delta ( $\Delta$ ) connection if the phase voltage is 100V. Also find the line current for delta ( $\Delta$ ) connection if the phase current is 5A.

## Solution

Term	Definition
<b>Phase Voltage</b>	Voltage across a single phase element
<b>Line Voltage</b>	Voltage between any two lines
<b>Phase Current</b>	Current flowing through a phase element
<b>Line Current</b>	Current flowing through a line

### Star (Y) Connection:

- Line voltage =  $\sqrt{3} \times \text{Phase voltage}$
- Line current = Phase current

Calculations:

- Line voltage =  $\sqrt{3} \times 100 = 173.2V$
- Line current = 5 A

### Delta ( $\Delta$ ) Connection:

- Line voltage = Phase voltage
- Line current =  $\sqrt{3} \times \text{Phase current}$

Calculations:

- Line voltage = 100 V
- Line current =  $\sqrt{3} \times 5 = 8.66A$

### Diagram:

#### Mermaid Diagram (Code)

```
{Shaded}  
{Highlighting} []  
graph TD  
    subgraph Star Connection  
        A1((R)) --- B1((Y))  
        B1 --- C1((B))  
        C1 --- A1  
        D1((N)) --- A1  
        D1 --- B1  
        D1 --- C1  
    end  
  
    subgraph Delta Connection  
        A2((R)) --- B2((Y))  
        B2 --- C2((B))  
        C2 --- A2  
    end  
{Highlighting}  
{Shaded}
```

## Mnemonic

“SLIP” - Star: Line voltage is  $\sqrt{3}$  times Phase voltage, In Delta : Phase voltage equals Line voltage

## Question 3(a) [3 marks]

State and explain Faraday’s laws of electromagnetic induction with necessary diagram and equations.

## Solution

### Faraday’s Laws:

1. **First Law:** When a conductor cuts magnetic flux, EMF is induced
2. **Second Law:** The magnitude of induced EMF is proportional to the rate of change of magnetic flux

**Equation:**  $e = -N \times (d/dt)W$  here :  $e = \text{induced EMF}$ ,  $N = \text{number of turns}$ ,  $d/dt = \text{rate of change of flux}$

Diagram:

#### Mermaid Diagram (Code)

```

{Shaded}
{Highlighting} []
graph LR
    A[Moving Magnet] --> B[Coil]
    B --> C[Galvanometer]
    D[Changing Magnetic Field] --> E[Induced EMF]
{Highlighting}
{Shaded}

```

### Mnemonic

“FIRE” - Flux change Induces Rapid EMF

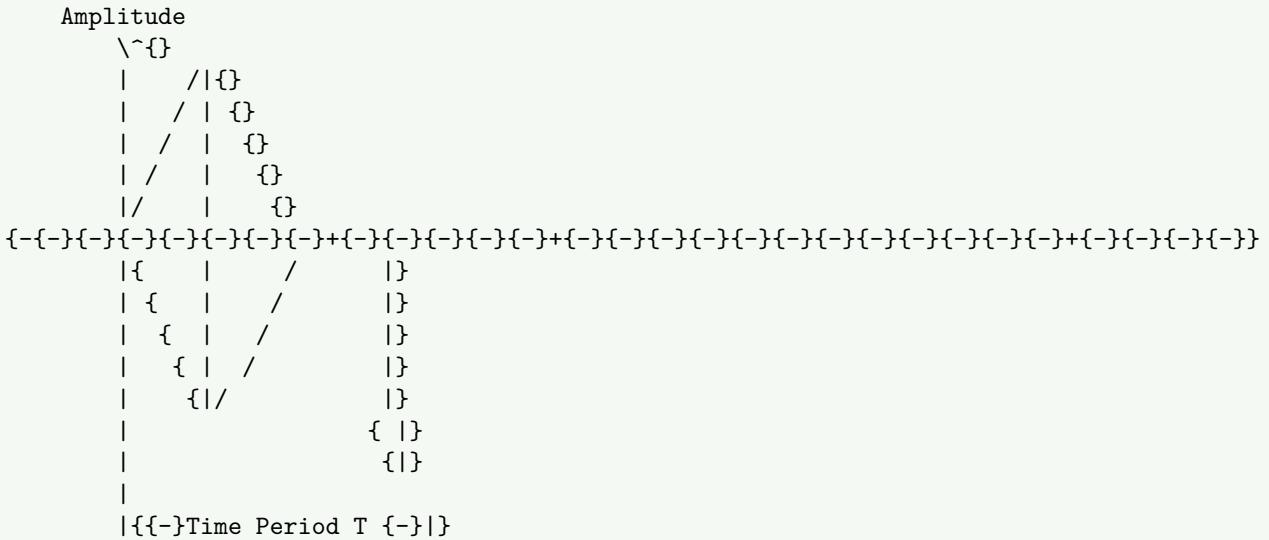
### Question 3(b) [4 marks]

Define amplitude, frequency, time duration and RMS value for alternating quantity.

### Solution

Parameter	Definition	Formula
<b>Amplitude</b>	Maximum value of the alternating quantity	$V_m$
<b>Frequency</b>	Number of complete cycles per second	$f = 1/T$
<b>Time Period</b>	Time taken to complete one cycle	$T = 1/f$
<b>RMS Value</b>	Effective value, equivalent to DC causing same heating	$V_{rms} = V_m/\sqrt{2} = 0.707V_m$

### Diagram:



### Mnemonic

“AFTR” - Amplitude is peak, Frequency is cycles per second, Time period is  $1/f$ , RMS is 0.707 times peak

### Question 3(c) [7 marks]

Explain self inductance and mutual inductance. (i) Find the self induction of the coil if total magnetic flux linked with the coil is 5 Wb-turns (micro Wb-turns) for 2 A current given to the coil (ii) Find the self induction of the coil, if the parameters of the coils are as follows: number of turns is 10, relative permeability of the material used for coil is 3, length of the coil is 5 cm and cross sectional area of coil is  $2 \text{ cm}^2$ .

## Solution

**Self Inductance:** Property of a coil to oppose change in current through it by inducing EMF in itself.

**Mutual Inductance:** Property of one coil to induce EMF in another coil due to change in current.

Part (i):

Self inductance ( $L$ ) = Flux linkage / Current

$L = 5 \text{ Wb-turns} / 2 \text{ A}$

$L = 2.5 \text{ H}$

Part (ii):

```
L = (_{o} \times N^2 \times A) / l
L = (4 \times 10^{-7} \times 3 \times 10^2 \times 2 \times 10^{-4}) / (5 \times 10^{-2})
L = (4 \times 3 \times 100 \times 2 \times 10^{-7}) / (5 \times 10^{-2})
L = (24 \times 10^{-5}) / (5 \times 10^{-2})
L = 24 \times 10^{-3} / 5
L = 4.8 \times 10^{-3}
L = 15.07 \text{ H}
```

Diagram:

Mermaid Diagram (Code)

```
{Shaded}
{Highlighting} []
graph TD
    subgraph Self Inductance
        A[Current in Coil] --> B[Magnetic Field]
        B --> C[EMF in Same Coil]
        end

    subgraph Mutual Inductance
        D[Current in Coil 1] --> E[Magnetic Field]
        E --> F[EMF in Coil 2]
        end
{Highlighting}
{Shaded}
```

## Mnemonic

“SLIM” - Self inductance Linked with own flux, Induction Mutual between two coils

## Question 3(a OR) [3 marks]

Define dynamically induced EMF. Explain it with the help of necessary diagram and equation.

## Solution

**Dynamically Induced EMF:** EMF induced in a conductor due to relative motion between the conductor and magnetic field.

Equation:  $e = Blv$  Where:  $e$  = induced EMF,  $B$  = magnetic flux density,  
 $l$  = length of conductor,  
 $v$  = velocity of conductor

Diagram:

Mermaid Diagram (Code)

```
{Shaded}
{Highlighting} []
graph LR
    A[Magnetic Field B] --> B[Moving Conductor]
    B --> C[Induced EMF e]
```

D [Motion with velocity v] {-{-}{-} B]  
 {Highlighting}  
 {Shaded}

### Mnemonic

“MOVE” - Motion Of conductor in magnetic field produces Voltage Effect

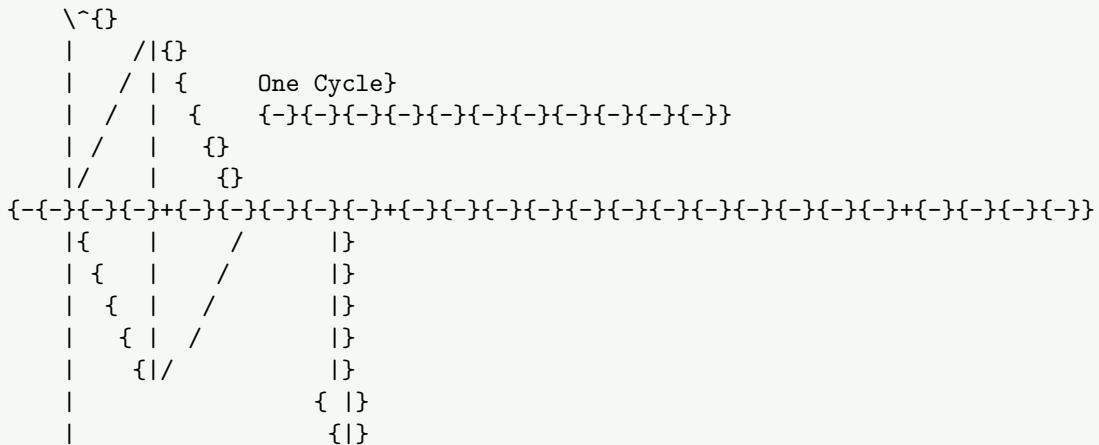
### Question 3(b OR) [4 marks]

Define cycle, Form Factor and Peak Factor for alternating quantity. Write the value of Form Factor and Peak Factor for sinusoidal alternating quantity.

### Solution

Term	Definition	Value for Sinusoidal Wave
Cycle	One complete oscillation of an alternating quantity	-
Form Factor	Ratio of RMS value to average value	1.11
Peak Factor	Ratio of maximum value to RMS value	1.414

Diagram:



$$\text{Form Factor} = V_{\text{rms}}/V_{\text{avg}} = 1.11$$

$$\text{Peak Factor} = V_m/V_{\text{rms}} = 1.414$$

### Mnemonic

“CFP” - Cycle is one oscillation, Form factor is 1.11, Peak factor is 1.414

### Question 3(c OR) [7 marks]

State and explain Lenz’s law. State and explain Fleming’s right hand rule for generator. Find the energy stored in inductor having self inductance of 4 H, if 3 A of current is flowing through the inductor.

### Solution

**Lenz’s Law:** The direction of induced EMF is such that it opposes the change in magnetic flux that produces it.

**Fleming’s Right Hand Rule:**

- Thum<sup>b</sup>: Direction of motion of conductor
- Index finger: Direction of magnetic field
- Middle finger: Direction of induced current

**Energy Calculation:**

```

Energy stored in inductor (W) =  $(1/2) \times L \times I^2$ 
W =  $(1/2) \times 4 \times 10^{-6} \times 3^2$ 
W =  $(1/2) \times 4 \times 10^{-6} \times 9$ 
W =  $18 \times 10^{-6} / 2$ 
W =  $9 \times 10^{-6}$  Joules
W = 9 J

```

#### Diagram:

Fleming's Right Hand Rule:

Thumb (Motion)  
Index (Field) ↑  
Middle (Current)

Lenz's Law:

N[---]S (Conductor)  
Induced current opposes motion

#### Mnemonic

“LOF” - Lenz’s law Opposes Flux change, Fleming’s rule - thumb Motion, index Field, middle Current

### Question 4(a) [3 marks]

Define PV cell. Explain the function of PV cell.

#### Solution

PV Cell: Photovoltaic cell is a semiconductor device that converts light energy directly into electrical energy.

##### Function:

- Absorbs photons from sunlight
- Creates electron-hole pairs in semiconductor
- Generates potential difference at p-n junction
- Converts solar energy to electrical energy

#### Diagram:

Mermaid Diagram (Code)

```

{Shaded}
{Highlighting} []
graph LR
    A["Sunlight"] --> B["PV Cell"]
    B --> C["DC Electricity"]
    D["P-type Silicon"] --- E["N-type Silicon"]
{Highlighting}
{Shaded}

```

#### Mnemonic

“PASE” - PV cell Absorbs Sunlight to generate Electricity

### Question 4(b) [4 marks]

Explain the classification of green energy.

## Solution

Green Energy Type	Source	Example Applications
Solar Energy	Sun	PV panels, solar thermal
Wind Energy	Air currents	Wind turbines
Hydro Energy	Flowing water	Dams, tidal, wave
Biomass Energy	Organic matter	Biofuels, biogas
Geothermal Energy	Earth's heat	Geothermal plants

Diagram:

Mermaid Diagram (Code)

```
{Shaded}  
{Highlighting} []  
graph TD  
    A[Green Energy] --> B[Solar]  
    A --> C[Wind]  
    A --> D[Hydro]  
    A --> E[Biomass]  
    A --> F[Geothermal]  
{Highlighting}  
{Shaded}
```

## Mnemonic

“SWHBG” - Sun, Wind, Hydro, Biomass, Geothermal energy sources

## Question 4(c) [7 marks]

Draw and explain the block diagram of solar power system.

## Solution

### Solar Power System Components:

Component	Function
Solar Panel	Converts sunlight to DC electricity
Charge Controller	Regulates battery charging and prevents overcharging
Battery Bank	Stores electricity for later use
Inverter	Converts DC to AC for household appliances
Distribution Panel	Distributes electricity to loads
Grid Connection	Optional connection to utility grid

### Block Diagram:

```
flowchart LR  
    A[Solar Panels] --> B[Charge Controller]  
    B --> C[Battery Bank]  
    C --> D[Inverter]  
    D --> E[Distribution Panel]  
    E --> F[Home Appliances]  
    E --> G[Grid Connection]
```

## Mnemonic

“SCBIDG” - Solar panels, Charge controller, Batteries, Inverter, Distribution, Grid

### Question 4(a OR) [3 marks]

Define green energy, conventional energy and renewable energy.

#### Solution

Term	Definition
Green Energy	Energy from naturally replenished sources with minimal environmental impact
Conventional Energy	Energy from traditional fossil fuel sources like coal, oil, and natural gas
Renewable Energy	Energy from sources that are naturally replenished on a human timescale

Diagram:

Mermaid Diagram (Code)

```
{Shaded}  
{Highlighting} []  
graph LR  
A[Energy Sources] --> B[Green/Renewable]  
A --> C[Conventional/Non-renewable]  
  
B --> D[Solar, Wind, Hydro, etc.]  
C --> E[Coal, Oil, Natural Gas]  
{Highlighting}  
{Shaded}
```

#### Mnemonic

“GCR” - Green is Clean, Conventional is Carbon-emitting, Renewable is Replenished

### Question 4(b OR) [4 marks]

Explain the need of green energy.

#### Solution

Need for Green Energy:

Need	Explanation
Environmental Protection	Reduces pollution and greenhouse gas emissions
Resource Conservation	Preserves limited fossil fuel resources
Energy Security	Reduces dependence on imported fuels
Economic Benefits	Creates jobs and reduces energy costs long-term
Sustainable Development	Meets present needs without compromising future generations

Diagram:

Mermaid Diagram (Code)

```
{Shaded}  
{Highlighting} []  
graph TD  
    A[Need for Green Energy] --> B[Environmental Protection]  
    A --> C[Resource Conservation]  
    A --> D[Energy Security]  
    A --> E[Economic Benefits]  
    A --> F[Sustainable Development]  
{Highlighting}  
{Shaded}
```

Mnemonic

“ERESS” - Environment, Resources, Energy security, Savings, Sustainability

### Question 4(c OR) [7 marks]

Draw and explain the block diagram of wind power system with types of turbines.

Solution

Wind Power System Components:

Component	Function
Wind Turbine	Converts wind energy to mechanical energy
Gearbox	Increases the rotational speed
Generator	Converts mechanical energy to electrical energy
Controller	Monitors and controls the system
Transformer	Steps up voltage for transmission
Grid Connection	Connects to the utility grid

Types of Wind Turbines:

1. Horizontal Axis Wind Turbine (HAWT) - Blades rotate around horizontal axis
2. Vertical Axis Wind Turbine (VAWT) - Blades rotate around vertical axis

Block Diagram:

```
flowchart LR  
    A[Wind] --> B[Wind Turbine]  
    B --> C[Gearbox]  
    C --> D[Generator]  
    D --> E[Controller]  
    E --> F[Transformer]  
    F --> G[Grid]  
  
    subgraph "Types of Turbines"  
        H[Horizontal Axis]  
        I[Vertical Axis]  
    end
```

Mnemonic

“WGGTC” - Wind turns turbine, Gearbox speeds up, Generator produces electricity, Transformer steps up, Controller manages

### Question 5(a) [3 marks]

Explain the factors affecting the value of resistance of a resistor.

## Solution

### Factors Affecting Resistance:

Factor	Effect
Temperature	Resistance increases with temperature in metals
Length	Resistance is directly proportional to length
Cross-sectional Area	Resistance is inversely proportional to area
Material	Different materials have different resistivities

$$\text{Equation: } R = \times(l/A)$$

Where:

- $R$  = Resistance
- $\times$  = Resistivity
- $l$  = Length
- $A$  = Cross-sectional area

## Mnemonic

“TLAM” - Temperature, Length, Area, Material affect resistance

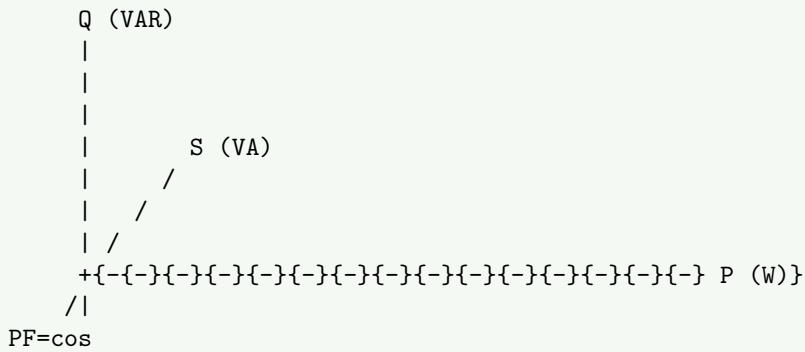
## Question 5(b) [4 marks]

Define active power, reactive power, apparent power and power factor with the help of power triangle. Write their units.

## Solution

Power Type	Definition	Formula	Unit
Active Power (P)	Actual power consumed	$P = VI \cos \theta$	Watt (W)
Reactive Power (Q)	Power oscillating between source and load	$Q = VI \sin \theta$	Volt-Ampere Reactive (VAR)
Apparent Power (S)	Product of voltage and current	$S = VI$	Volt-Ampere (VA)
Power Factor (PF)	Ratio of active power to apparent power	$PF = P/S = \cos \theta$	No unit (0 to 1)

## Power Triangle:



## Mnemonic

“ARSP” - Active is Real power in Watts, Reactive is Stored power in VAR, S is total VA, PF is cos

### Question 5(c) [7 marks]

State and explain Kirchhoff's Voltage Law (KVL) and Kirchhoff's Current Law (KCL) with the help of circuit diagram.

#### Solution

**Kirchhoff's Voltage Law (KVL):** The algebraic sum of all voltages around any closed loop in a circuit is zero.

**Kirchhoff's Current Law (KCL):** The algebraic sum of all currents entering and leaving a node is zero.

Law	Equation	Application
KVL	$= 0$	Finding voltage in complex circuits
KCL	$= 0$	Finding current distribution

Circuit Diagrams:

Mermaid Diagram (Code)

```
{Shaded}  
{Highlighting} []  
graph TD  
    subgraph KVL  
        A1(({}+)) --> B1[R1]  
        B1 --> C1[R2]  
        C1 --> D1[R3]  
        D1 --> A1  
    end  
  
    subgraph KCL  
        A2((Node)) --> B2[I1]  
        A2 --> C2[I2]  
        A2 --> D2[I3]  
        A2 --> E2[I4]  
    end  
{Highlighting}  
{Shaded}
```

**KVL Example:**  $V_1 + V_2 + V_3 = 0$

**KCL Example:**  $I_1 + I_2 = I_3 + I_4$

#### Mnemonic

“VCL” - Voltage around Closed Loop is zero, Currents at a point sum to zero

### Question 5(a OR) [3 marks]

Write the difference between EMF and potential difference. Also write the difference between cell and battery.

#### Solution

EMF vs. Potential Difference	Cell vs. Battery
EMF: Energy supplied by source per unit charge	Cell: Single unit that converts chemical energy to electrical energy
Potential Difference: Energy consumed in external circuit	Battery: Collection of two or more cells connected in series or parallel

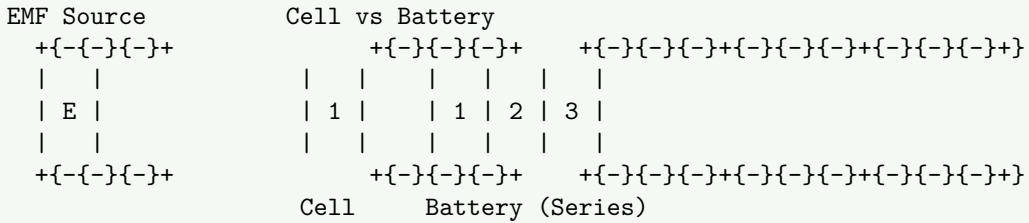
EMF exists even in open circuit

Potential difference exists only in closed circuit

Cell has lower voltage (typically 1.5V or 2V)

Battery has higher voltage output

Diagram:



Mnemonic

"ESOP" - EMF is Source energy, Open circuit too; Potential difference is Operating energy

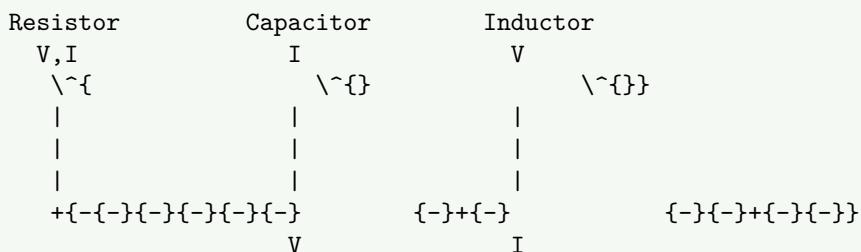
### Question 5(b OR) [4 marks]

Write the relation between AC voltage and AC current for pure resistor, pure capacitor and pure inductor. Draw the vector diagram of AC voltage and AC current for pure resistor, pure capacitor and pure inductor. Also write the value of power factor for pure resistor, pure capacitor and pure inductor.

Solution

Component	Relation	Phase Difference	Power Factor
Pure Resistor	$V = IR$	In phase ( $0^\circ$ )	1
Pure Capacitor	$I = C(dV/dt)$	Current leads voltage by $90^\circ$	0 (leading)
Pure Inductor	$V = L(dI/dt)$	Current lags voltage by $90^\circ$	0 (lagging)

Vector Diagrams:



Mnemonic

"RCI" - Resistor Current In phase, Capacitor current leads, Inductor current lags

### Question 5(c OR) [7 marks]

Define temperature coefficient of material and write its unit. Explain the effect of temperature on resistance of conductor with the help of temperature coefficient of conductor.

Solution

Temperature Coefficient: The fractional change in resistance per degree change in temperature.

Unit: per degree Celsius ( ${}^{\circ}\text{C}^{-1}$ ) or per Kelvin ( $K^{-1}$ )

Effect of Temperature on Resistance:

Equation:  $R_2 = R_1[1 + (T_2 - T_1)]$

Where:

- $R_1$  = Resistance at temperature  $T_1$
- $R_2$  = Resistance at temperature  $T_2$
- $\alpha$  = Temperature coefficient
- $T_1, T_2$  = Initial and final temperatures

For Conductors (Metals):

- Resistance increases with temperature (positive)
- Resistance decreases when temperature decreases

For Semiconductors:

- Resistance decreases with temperature (negative)

Material	Temperature Coefficient ( ) per	Behavior
Copper	0.0043	Resistance increases with temperature
Aluminum	0.0039	Resistance increases with temperature
Nichrome	0.0004	Small change with temperature
Silicon	-0.07	Resistance decreases with temperature

Diagram:

Mermaid Diagram (Code)

```
{Shaded}  
{Highlighting} []  
graph LR  
    A[Temperature Increase] --> B[Increased Atomic Vibrations]  
    B --> C[More Electron Collisions]  
    C --> D[Increased Resistance in Metals]  
{Highlighting}  
{Shaded}
```

### Mnemonic

“TRIP” - Temperature Raises resistance In Proportion to coefficient