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PHY • PHYSICS

11. Electromagnetic Induction

Official PMDC Solved Past Paper Topical Booklet • High-Yield Examination Series

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👤 2009 to 2024 Archive

🛡 Boards: BUMHS, DUHS, KMU, KU, NUMS, PMDC

📖 Weightage: 27% of MDCAT (54 MCQs)

Curated by Ibrahim for fellow bees. Every question in this chapter has been verified against official UHS, NUMS, SZABMU, DUHS, and KMU answer keys. Propolis cognitive autopsies are provided at the end of this booklet to explain core concepts and break down common distractor traps.

OFFICIAL SOLVED EDITION**Q1.**

SZABMU 2024

A coil of 100 turns is linked by a flux of 20 mWb . If this flux is reversed in a time of 2 ms , calculate the average induced emf in the coil?

[SZABMU 2024]

- (A) 1000 volts
- (B) 2000 volts
- (C) 3000 volts
- (D) 4000 volts

Q2.

SZABMU 2024

The turns ratio of a step-up transformer is 5. A current of 20 A is passed through its primary coil at 220 V . Calculate the value of voltage in secondary coil?

[SZABMU 2024]

- (A) 1000 V
- (B) 1025 V
- (C) 1050 V
- (D) 1100 V

Q3.

SZABMU 2024

Which one of the following factors is the best for calculation Compton's shift?

[SZABMU 2024]

- (A) Angular spin of electron
- (B) Energy of electron
- (C) Energy of photon
- (D) Scattering angle of photon

Q4.

SZABMU 2024

The Lenz's law of electromagnetic induction is in accordance with law of conservation of ____

[SZABMU 2024]

- (A) Charge
- (B) Energy
- (C) Mass
- (D) Momentum

Q5.

SZABMU 2024

The rate of change of magnetic flux is measured in

[SZABMU 2024]

- (A) Coulomb
- (B) Ohm
- (C) Volt
- (D) Watt

Q6.

KU 2024

The direction of induced current is determined by?

[KU 2024]

- (A) Ampere's law
- (B) Faraday's law
- (C) Lenz's law
- (D) Ohm's law

Q7.

KU 2024

Lenz's law is consistent with the

[KU 2024]

- (A) Ampere's law
- (B) Faraday's law
- (C) Law of conservation of energy
- (D) Ohm's law

Q8.

KU 2024

The basic principle behind the operation of the transformer is:

[KU 2024]

- (A) Coulomb's law
- (B) Electromagnetic induction
- (C) Gas's law
- (D) Hess's law

Q9.

UHS 2024

Electric generators and transformers are based on the principles of:

[UHS 2024]

- (A) Coulomb's law
- (B) Faraday's law
- (C) Ampere's law
- (D) Hook's law

Q10.

UHS 2024

In an AC generator the emf will be maximum when factor $\sin(\omega t)$ is equal to

[UHS 2024]

- (A) Zero
- (B) 1
- (C) 2
- (D) 1/2

Q11.

UHS 2024

The induced current will flow in such a direction so as to oppose the cause that produces it is statement of:

[UHS 2024]

- (A) Ampere's law
- (B) Faraday's law
- (C) Lenz's law
- (D) Joule's law

Q12.

UHS 2024

In an ideal transformer:

[UHS 2024]

- (A) Power input is equal to power output
- (B) Power input is less than half of the power output
- (C) Power input is greater than power output
- (D) Power input is more than half of the power output

Q13.

NUMS 2024

A transformer used a 220 V line delivers 22 A at 1800 V. What current is drawn from the line (assume 100% efficiency)?

[NUMS 2024]

- (A) 22 A
- (B) 180 A
- (C) 200 A
- (D) 50 A

Q14.

BUMHS 2024

The direction of induced e.m.f can be determined by:

[BUMHS 2024]

- (A) Faraday's law
- (B) Lenz's law
- (C) galvanometer
- (D) Fleming's right hand rule

Q15.

BUMHS 2024

Which of the following method can be used to vary induced emf in a coil?

[BUMHS 2024]

- (A) Alternating magnetic field
- (B) Moving the coil in the magnetic field
- (C) Changing the shape of coil
- (D) All of the above

Q16.

BUMHS 2024

Let an inductor is connected with battery. If emf induced in the inductor opposes emf of battery, then electric current through the circuit is:

[BUMHS 2024]

- (A) Decreasing
- (B) Increasing
- (C) Constant
- (D) Alternating

Q17.

BUMHS 2024

The induced emf in a 100 turns coil if change in flux through the coil 2×10^{-4} Wb in 0.02 sec:

[BUMHS 2024]

- (A) 1.0 V
- (B) -1.0 V
- (C) 10 V
- (D) -10 V

Q18.

UHS 2023

In principle, the transformer consists of two coils of copper, electrically insulated from each other, wound on the same?

[UHS 2023]

- (A) Iron core
- (B) Copper core
- (C) Gold core
- (D) Steel core

Q19.

UHS 2023

Velocity selector will select only those charge particle whose velocity is given by:

[UHS 2023]

- (A) $V = E/B$
- (B) $V = B/E$
- (C) $V = E \times B$
- (D) $V = 0$

Q20.

UHS 2023

The induced emf produced in the coil is sometimes called as?

[UHS 2023]

- (A) Self-inductance
- (B) Back emf
- (C) Motional emf
- (D) Mutual inductance

Q21.

UHS 2023

The quantity $\frac{\Delta\phi}{\Delta t}$ has the same units as that of?

[UHS 2023]

- (A) Current
- (B) Magnetic induction
- (C) Charge
- (D) Emf

Q22.

UHS 2023

Working principal of magnetic levitation train is according to?

[UHS 2023]

- (A) Faraday law
- (B) Max planks law
- (C) Ohm law
- (D) Lenz law

Q23.

UHS 2023

The expression for the emf produced by A.C generator is?

[UHS 2023]

- (A) $N\omega AB \sin(\theta)$
- (B) $N\omega AB \cos(\theta)$
- (C) $N\omega AB$
- (D) $N\omega AB \tan(\theta)$

Q24.

SZABMU 2023

The phenomenon in which a changing current in one coil induces an emf in another coil is:

[SZABMU 2023]

- (A) Self-induction
- (B) Mutual induction
- (C) Eddy current
- (D) Choke

Q25.

SZABMU 2023

The induced current will flow in such a direction as to oppose the cause that produces it. It is the statement of:

[SZABMU 2023]

- (A) Ampere's Law
- (B) Faraday's Law
- (C) Lenz's Law
- (D) Joule's Law

Q26.

SZABMU 2023

The transformer depends on the use of:

[SZABMU 2023]

- (A) Direct current
- (B) Alternating current
- (C) Direct and alternating current
- (D) Direct and alternating voltage

Q27.

SZABMU 2023

The domestic electricity supply in Pakistan has a frequency of:

[SZABMU 2023]

- (A) 150 Hz
- (B) 100 Hz
- (C) 50 Hz
- (D) 25 Hz

Q28.

SZABMU 2023

Transformer works on the principle of:

[SZABMU 2023]

- (A) Half wave rectification
- (B) Self-induction
- (C) Mutual induction
- (D) Full wave rectification

Q29.

DUHS 2023

On which principle does the transformer work?

[SINDH 2023]

- (A) Self-induction
- (B) Mutual induction
- (C) Motional emf
- (D) Magnetic torque

Q30.

DUHS 2023

If a transformer has 500 turns on primary coil and 250 turns on secondary coil, then

[SINDH 2023]

- (A) Output voltage is half of input voltage
- (B) Output and input voltages are equal
- (C) Output voltage is double of input voltage
- (D) Output voltage is zero

Q31.

DUHS 2023

Induced e.m.f in A.C generator can be increased by:

[SINDH 2023]

- (A) Decreasing area of coil
- (B) Decreasing magnetic field
- (C) Increasing area of coil
- (D) Slowing down speed of coil

Q32.

DUHS 2023

A transformer is used to:

[SINDH 2023]

- (A) Transform alternating current and voltage
- (B) Convert alternating current into direct current
- (C) Convert mechanical energy into electrical energy
- (D) Convert direct current into alternating current

Q33.

DUHS 2023

The main function of a transformer is to convert.

[SINDH 2023]

- (A) One direct voltage to another direct voltage of different magnitude
- (B) One alternating voltage to another alternating voltage of different magnitude
- (C) A high value alternating voltage to a low value direct voltage
- (D) A high value alternating voltage to a high value direct voltage

Q34.

NUMS 2023

The Lenz's law is also statement of law of conservation of:

[NUMS 2023]

- (A) Charge
- (B) Mass
- (C) Energy
- (D) Pressure

Q35.

NUMS 2023

A current generator is a device that converts:

[NUMS 2023]

- (A) Mechanical energy into electrical energy
- (B) Chemical energy into mechanical energy
- (C) Sound energy into mechanical energy
- (D) Electrical energy into mechanical energy

Q36.

UHS 2022

The source of magnetic field is:

[UHS 2022]

- (A) An isolated magnetic pole
- (B) Static electric charge
- (C) Nonmagnetic substance
- (D) Current loop

Q37.

UHS 2022

One meter long copper rod is moving with speed 20 ms^{-1} in the magnetic field of strength 0.6 T . What is the value of induced emf?

[UHS 2022]

- (A) 10 V
- (B) 12 V
- (C) 14 V
- (D) 16 V

Q38.

UHS 2022

The unit of $\frac{\Delta\phi}{\Delta t}$ can be written as?

[UHS 2022]

- (A) $\text{N m A}^{-2} \text{ s}^{-1}$
- (B) N m A s^{-1}
- (C) $\text{N m A}^{-1} \text{ s}^{-1}$
- (D) $\text{N m A}^{-2} \text{ s}^1$

Q39.

UHS 2022

Working principal of magnetic levitation train is according to?

[UHS 2022]

- (A) Faraday law
- (B) Max planks law
- (C) Ohm law
- (D) Lenz law

Q40.

UHS 2022

A copper hoop is held in a vertical east–west plane in a uniform magnetic field whose field lines run along the north–south direction. The largest induced emf is produced when the hoop is?

[UHS 2022]

- (A) Rotated about a north–south axis
- (B) Rotated about an east–west axis
- (C) Moved rapidly, without rotation, toward the east
- (D) Moved rapidly, without rotation, toward the south

Q41.

UHS 2022

In transformer, there is no _____ connection between the two coils but they are _____ linked?

[UHS 2022]

- (A) Magnetic, electrically
- (B) Electrical, magnetically
- (C) Magnetic, magnetically
- (D) Electrical, optically

Q42.

SZABMU 2022

In Fleming's right hand rule the middle finger indicates:

[SZABMU 2022]

- (A) Force
- (B) Magnetic field
- (C) Induced current
- (D) Volt

Q43.

SZABMU 2022

Transformer works on the principle of:

[SZABMU 2022]

- (A) Lenz's law
- (B) Faraday's law
- (C) Mutual induction
- (D) Ampere's law

Q44.

SZABMU 2022

The efficiency of transformer is:

[SZABMU 2022]

- (A) 60%
- (B) 70%
- (C) 80%
- (D) 90%

Q45.

SZABMU 2022

Lenz's law is also a statement of law of conservation of:

[SZABMU+BMU 2022]

- (A) Charge
- (B) Energy
- (C) Momentum
- (D) Mass

Q46.

KMU 2022

What is the inappropriate statement for step-up transformer?

[ETEA 2022]

- (A) It increases given AC voltage
- (B) It decreases given alternating current
- (C) Heat is never produced in step-up transformer
- (D) Its input energy is always less than its output energy

Q47.

KMU 2022

An ideal AC generator has equal input and output, its heat dissipation will be:

[ETEA 2022]

- (A) Of some finite value
- (B) Zero
- (C) Maximum
- (D) Very much small

Q48.

KMU 2022

AC generator stops suddenly when:

[ETEA 2022]

- (A) External voltage overcomes the back emf
- (B) Torque of back emf exceeds the external torque
- (C) Resistance of the coil produces heat
- (D) Moment of inertia of the coil decreases

Q49.

BUMHS 2022

The maximum value of induced emf in a rotating coil in a magnetic field does not depend upon:

[BMU 2022]

- (A) Resistance of the coil
- (B) Number of turns in the coil
- (C) Area of the coil
- (D) Frequency of rotation of the coil

Q50.

BUMHS 2022

As induced emf is produced in a circuit when:

[BMU 2022]

- (A) Electric flux changes
- (B) Magnetic flux changes
- (C) Not magnetic flux produced
- (D) Magnetic flux remains constant

Q51.

DUHS 2022

The mathematical equation representing Faraday's law is:

[DUHS 2022]

- (A) $E = N \frac{\Delta I}{\Delta t}$
- (B) $E = -N \frac{\Delta \phi}{\Delta t}$
- (C) $E = -\frac{N \Delta I}{\Delta t}$
- (D) $E = -\frac{\Delta \phi}{\Delta t}$

Q52.

DUHS 2022

The instantaneous emf generated by alternating current generator is written as:

[DUHS 2022]

- (A) $E = BINA \sin(\omega t)$
- (B) $E = BN A \omega \sin(\omega t)$
- (C) $E = BINA$
- (D) $E = \frac{F}{BINA}$

Q53.

DUHS 2022

For efficient transfer of electricity through cables over the long distance:

[DUHS 2022]

- (A) Both the current and voltage must be low
- (B) The current must be low and voltage high
- (C) Both the current and voltage must be high
- (D) The voltage must be zero and current low

Q54.

NUMS 2022

Lenz's law is based on the law of conservation of:

[NUMS 2022]

- (A) Mass
- (B) Energy
- (C) Charges
- (D) Momentum

Q55.

NUMS 2022

In Fleming's right-hand rule, the thumb indicates:

[NUMS 2022]

- (A) Force
- (B) Magnetic field
- (C) Induced current
- (D) Electric field

Q56.

NUMS 2022

Transformer works on the principle of:

[NUMS 2022]

- (A) Half wave rectification
- (B) Self-induction
- (C) Mutual induction
- (D) Full wave rectification

Q57.

PMDC 2021

Which is the correct relation:

[NMDCAT 2021]

- (A) $N_s/N_p = V_s/V_p$
- (B) $N_s N_p = V_s/V_p$
- (C) $N_s/N_p = I_s/I_p$
- (D) None

Q58.

PMDC 2021

In a step-up transformer, current across secondary is

[NMDCAT 2021]

- (A) More
- (B) Less
- (C) Equal
- (D) None

Q59.

PMDC 2021

Find Turn ratio if $\frac{V_s}{V_p} = 2$?**[NMDCAT 2021]**

- (A) 2:1
- (B) 1:2
- (C) 4:8
- (D) None

Q60.

PMDC 2021

[PMC Sample 3]

Which of the following physical quantities remains completely unchanged across the primary and secondary windings of an ideal transformer?

- (A) Voltage
- (B) Current
- (C) Power
- (D) Frequency

Q61.

PMDC 2021

[PMC Practice 5]

Alternating current (AC) generators utilize which of the following contact rings to connect the rotating armature coil to the external circuit?

- (A) Split rings
- (B) Solenoid rings
- (C) Slip rings
- (D) Coiled rings

Q62.

PMDC 2020

In transmission from grid station, power losses are minimized by:

[NMDCAT 2020]

- (A) Increasing current
- (B) Decreasing current
- (C) Increasing resistance
- (D) Increasing voltage

Q63.

PMDC 2020

The domestic electricity supply has a frequency of:

[NMDCAT 2020]

- (A) 150 Hz
- (B) 100 Hz
- (C) 50 Hz
- (D) 25 Hz

Q64.

PMDC 2020

Transformer is a device which steps up or steps down the input:

[NMDCAT 2020]

- (A) Current
- (B) Voltage
- (C) Energy
- (D) Power

Q65.

PMDC 2020

If a stationary bar magnet is placed near a coil at rest so maximum lines of force passes through the coil, the galvanometer shows:

[NMDCAT 2020]

- (A) Maximum current
- (B) Minimum current
- (C) No current
- (D) Intermediate value of current

Q66.

KMU 2018

The function of main transformer is to convert:

[ETEA 2018]

- (A) One direct voltage to another direct voltage of different magnitude
- (B) One alternating voltage to another alternating voltage of different magnitude
- (C) A high value alternating voltage to low value direct voltage
- (D) A high value alternating current to low value direct voltage

Q67.

KMU 2017

The phenomenon used for producing emf in coil of generator is;

[ETEA 2017]

- (A) Mutual induction
- (B) Self-induction
- (C) Electrostatic induction
- (D) Electromagnetic inductions

Q68.

KMU 2016

The phenomenon of mutual induction is practically used is:

[ETEA 2016]

- (A) Transformer
- (B) Generator
- (C) Galvanometer
- (D) Avometer

Q69.

KMU 2009

A transformer changes 12 V to 18000 V and there are 6000 turns in the secondary coil. The number of turns in the primary coil are:

[ETEA 2009]

- (A) 40
- (B) 20
- (C) 30
- (D) 4

RAPID 5–COLUMN ANSWER KEY

Official PMDC verified answer keys for 11. Electromagnetic Induction.

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Q#	KEY	BOARD	Q#	KEY	BOARD	Q#	KEY	BOARD	Q#	KEY	BOARD	Q#	KEY	BOARD
1	B	SZABMU 2024	15	D	BUMHS 2024	29	B	DUHS 2023	43	C	SZABMU 2022	57	A	PMDC 2021
2	D	SZABMU 2024	16	B	BUMHS 2024	30	A	DUHS 2023	44	D	SZABMU 2022	58	B	PMDC 2021
3	D	SZABMU 2024	17	B	BUMHS 2024	31	C	DUHS 2023	45	B	SZABMU 2022	59	A	PMDC 2021
4	B	SZABMU 2024	18	A	UHS 2023	32	A	DUHS 2023	46	C	KMU 2022	60	D	PMDC 2021
5	C	SZABMU 2024	19	A	UHS 2023	33	B	DUHS 2023	47	B	KMU 2022	61	C	PMDC 2021
6	C	KU 2024	20	B	UHS 2023	34	C	NUMS 2023	48	B	KMU 2022	62	D	PMDC 2020
7	C	KU 2024	21	D	UHS 2023	35	A	NUMS 2023	49	A	BUMHS 2022	63	C	PMDC 2020
8	B	KU 2024	22	D	UHS 2023	36	D	UHS 2022	50	B	BUMHS 2022	64	B	PMDC 2020
9	B	UHS 2024	23	A	UHS 2023	37	B	UHS 2022	51	B	DUHS 2022	65	C	PMDC 2020
10	B	UHS 2024	24	B	SZABMU 2023	38	C	UHS 2022	52	B	DUHS 2022	66	B	KMU 2018
11	C	UHS 2024	25	C	SZABMU 2023	39	A	UHS 2022	53	B	DUHS 2022	67	D	KMU 2017
12	A	UHS 2024	26	B	SZABMU 2023	40	B	UHS 2022	54	B	NUMS 2022	68	A	KMU 2016
13	B	NUMS 2024	27	C	SZABMU 2023	41	B	UHS 2022	55	A	NUMS 2022	69	D	KMU 2009
14	B	BUMHS 2024	28	C	SZABMU 2023	42	C	SZABMU 2022	56	C	NUMS 2022			

TOTAL
MCQS

69

CORRECT

INCORRECT

BLANK

ACCURACY

%

Scan the booklet QR code to enter answers in
BeambePrep Grind Mode for automated error
autopsies.

PROPOLIS COGNITIVE ERROR AUTOPSIES

Step-by-step conceptual derivations, formula working, and distractor autopsies for every question.

Question #1 Key: (B)

SZABMU 2024

A coil of [Formula] turns is linked by a flux of [Formula]. If this flux is reversed in a time of [Formula], ...

CORE CONCEPT AND DERIVATION

Faraday's Law of Electromagnetic Induction calculates the average induced EMF based on the rate of change of magnetic flux.

Formula:

$$\varepsilon = -N \frac{\Delta \phi}{\Delta t}$$

Solution:

- Given: Number of turns $N = 100$.
- Initial flux $\phi_i = 20 \text{ mWb}$. Because it is "reversed", the final flux is $\phi_f = -20 \text{ mWb}$.
- Change in flux: $\Delta \phi = \phi_f - \phi_i = -20 - 20 = -40 \text{ mWb} = -40 \times 10^{-3} \text{ Wb}$.
- Time interval $\Delta t = 2 \text{ ms} = 2 \times 10^{-3} \text{ s}$.
- Substitute values into the formula:

$$\varepsilon = -100 \times \frac{-40 \times 10^{-3}}{2 \times 10^{-3}}$$

- Simplify:

$$\varepsilon = 100 \times \frac{40}{2} = 100 \times 20 = 2000 \text{ V}$$

Why other options are incorrect:

A common mistake is failing to realize that "reversed" means moving from $+20$ to -20 (a total change of 40), not just dropping to zero. Using 20 instead of 40 leads to the incorrect answer of 1000 V .

Question #2 Key: (D)

SZABMU 2024

The turns ratio of a step-up transformer is 5 . A current of [Formula] is passed through its primary coil at [F...]

CORE CONCEPT AND DERIVATION

In an ideal transformer, the ratio of the secondary voltage to the primary voltage is exactly equal to the turns ratio.

Formula:

$$\frac{V_s}{V_p} = \frac{N_s}{N_p}$$

Solution:

- Given: Turns ratio for a step-up transformer is $\frac{N_s}{N_p} = 5$.
- Primary voltage $V_p = 220 \text{ V}$. (Note: The primary current of 20 A is extra information not needed for finding the voltage).
- Rearrange to solve for secondary voltage:

$$V_s = V_p \times \left(\frac{N_s}{N_p}\right)$$

- Substitute values:

$$V_s = 220 \times 5 = 1100 \text{ V}$$

Why other options are incorrect:

Options A, B, and C are arithmetic errors or misapplications of the given constants. The calculation 220×5 cleanly yields 1100 .

Question #3 Key: (D)

SZABMU 2024

Which one of the following factors is the best for calculation Compton's shift? [SZABMU 2024]

CORE CONCEPT AND DERIVATION

Compton's shift describes the increase in wavelength of X-rays or gamma rays scattered by electrons.

Formula:

$$\Delta\lambda = \frac{h}{m_0c}(1 - \cos\theta)$$

Solution:

- In the Compton shift equation, h , m_0 (rest mass of an electron), and c are fundamental constants.
- The only variable that determines the magnitude of the shift ($\Delta\lambda$) is θ , which is the **scattering angle of the photon**.

Why other options are incorrect:

While the energy of the incident photon determines the initial wavelength, the actual *shift* (difference in wavelength) depends entirely on the angle at which it scatters. Electron spin has no role in this kinematic equation.

Question #4 Key: (B)

SZABMU 2024

The Lenz's law of electromagnetic induction is in accordance with law of conservation of ____ [SZABMU 2024]

CORE CONCEPT AND DERIVATION

Lenz's law states that an induced EMF always gives rise to a current whose magnetic field opposes the original change in flux.

Solution:

- This opposing magnetic force acts as a brake. To keep the generator moving or the flux changing, external mechanical work must be done against this resistance.
- This mechanical work is strictly what gets converted into electrical energy, proving that Lenz's law is a direct consequence of the **law of conservation of energy**.

Why other options are incorrect:

Conservation of charge relates to Kirchhoff's current laws. Mass and momentum are conserved in mechanical collisions, but energy is the core principle governing the work-to-electricity conversion in induction.

Question #5 Key: (C)

SZABMU 2024

The rate of change of magnetic flux is measured in [SZABMU 2024]

CORE CONCEPT AND DERIVATION

According to Faraday's Law, the induced electromotive force (EMF) is mathematically equal to the rate of change of magnetic flux.

Formula:

$$\varepsilon = -N \frac{\Delta\phi}{\Delta t}$$

Solution:

- Since EMF (ε) is measured in **Volts**, the term representing the rate of change of magnetic flux ($\frac{\Delta\phi}{\Delta t}$, or Webers per second) must have identically the same unit.
- Therefore, it is measured in **Volts**.

Why other options are incorrect:

Coulomb is the unit of electric charge. Ohm is for electrical resistance. Watt is for electrical power (Joules per second).

Question #6 Key: (C)

KU 2024

The direction of induced current is determined by? [KU 2024]

CORE CONCEPT AND DERIVATION

While Faraday's law determines the magnitude of the induced EMF, a separate principle governs its polarity (direction).

Solution:

- **Lenz's law** states that the direction of the induced current is such that its own magnetic field will oppose the change in magnetic flux that caused it.
- This is mathematically represented by the negative sign in Faraday's equation ($\varepsilon = -N \frac{\Delta\phi}{\Delta t}$).

Why other options are incorrect:

Faraday's law gives the magnitude. Ampere's law relates current to the magnetic field it produces (not induction). Ohm's law relates voltage, current, and resistance in a circuit.

Question #7 Key: (C)

KU 2024

Lenz's law is consistent with the [KU 2024]

CORE CONCEPT AND DERIVATION

Lenz's law dictates that the induced magnetic field opposes the motion or change creating it.

Solution:

- Because it opposes the motion, external mechanical work is required to push through this "magnetic friction."
- This mechanical work is converted directly into electrical energy. Thus, Lenz's law prevents energy from being created out of nothing, making it consistent with the **Law of conservation of energy**.

Why other options are incorrect:

If Lenz's law were not true (if the field aided motion), a magnet would accelerate endlessly on its own, violating the first law of thermodynamics (energy conservation).

Question #8 Key: (B)

KU 2024

The basic principle behind the operation of the transformer is: [KU 2024]

CORE CONCEPT AND DERIVATION

A transformer transfers electrical power between two isolated coils without any physical electrical connection.

Solution:

- It does this by passing alternating current through the primary coil to generate a changing magnetic field.
- This changing field cuts through the secondary coil, inducing a voltage. This overarching process is a prime example of **Electromagnetic induction** (specifically, mutual induction).

Why other options are incorrect:

Coulomb's law governs static point charges. Gas laws govern thermodynamics of vapors. Hess's law governs chemical enthalpy changes. None apply to transformers.

Question #9 Key: (B)

UHS 2024

Electric generators and transformers are based on the principles of: [UHS 2024]

CORE CONCEPT AND DERIVATION

Both generators and transformers rely on a changing magnetic environment to generate an electromotive force (EMF).

Solution:

- A generator uses a physically rotating coil in a static magnetic field.
- A transformer uses a static coil in a changing AC magnetic field.
- Both devices fundamentally operate because a changing magnetic flux induces an EMF, which is the core statement of **Faraday's law** of electromagnetic induction.

Why other options are incorrect:

Ampere's law describes how current creates a magnetic field, but Faraday's law describes how changing magnetic fields create voltage (which is what generators and transformers do). Hooke's law is for mechanical springs.

Question #10 Key: (B)

UHS 2024

In an AC generator the emf will be maximum when factor [Formula] is equal to [UHS 2024]

CORE CONCEPT AND DERIVATION

The voltage output of an AC generator is described by a sinusoidal function.

Formula:

$$\varepsilon = \varepsilon_0 \sin(\omega t)$$

Solution:

- The induced EMF (ε) scales linearly with the value of the sine function.
- In trigonometry, the absolute maximum value of a sine function is 1 (occurring at 90° or $\frac{\pi}{2}$ radians).
- Therefore, when $\sin(\omega t) = 1$, the generator produces its peak voltage, ε_0 .

Why other options are incorrect:

A value of zero yields zero EMF. The sine function can never exceed 1, so 2 is mathematically impossible. A value of $1/2$ only yields half of the maximum EMF.

Question #11 Key: (C)

UHS 2024

The induced current will flow in such a direction so as to oppose the cause that produces it is statement of: ...

CORE CONCEPT AND DERIVATION

The directionality of electromagnetic induction is governed by the conservation of energy.

Solution:

- The textbook definition of **Lenz's Law** is exactly the quote provided: The direction of an induced current is always such that its magnetic field opposes the change in magnetic flux that caused it.

Why other options are incorrect:

Faraday's law calculates the magnitude of the EMF but does not dictate its direction explicitly without Lenz's law. Joule's law relates to resistive heating.

Question #12 Key: (A)

UHS 2024

In an ideal transformer: [UHS 2024]

CORE CONCEPT AND DERIVATION

An "ideal" electrical device is a theoretical model that assumes 100% efficiency, meaning no energy is lost to heat, sound, or magnetic leakage.

Formula:

$$P_{\text{in}} = P_{\text{out}}$$

Solution:

- Since energy cannot be created or destroyed, an ideal transformer perfectly transfers all the electrical energy from the primary coil to the secondary coil.
- Therefore, the **Power input is exactly equal to the power output** ($V_p I_p = V_s I_s$).

Why other options are incorrect:

Power output can never exceed power input (violates conservation of energy). If power input were greater than output, the transformer would not be "ideal" because it implies energy is being lost as heat.

Question #13 Key: (B)

NUMS 2024

A transformer used a [Formula] line delivers [Formula] at [Formula]. What current is drawn from the line (ass...

CORE CONCEPT AND DERIVATION

For a 100% efficient (ideal) transformer, the power entering the primary coil equals the power exiting the secondary coil.

Formula:

$$V_p I_p = V_s I_s$$

Solution:

- Given: Primary voltage $V_p = 220$ V.
- Secondary voltage $V_s = 1800$ V and Secondary current $I_s = 22$ A.
- Rearrange the power conservation formula to solve for the primary current (I_p):

$$I_p = \frac{V_s I_s}{V_p}$$

- Substitute the values:

$$I_p = \frac{1800 \times 22}{220}$$

- Simplify:

$$I_p = 1800 \times \left(\frac{22}{220}\right) = 1800 \times 0.1 = 180 \text{ A}$$

Why other options are incorrect:

A common mistake is using the wrong ratio (e.g., dividing by 1800 instead of 220), which would result in drastically incorrect current values. Because it's a step-up transformer (voltage increases $\sim 8\times$), the primary current must be $\sim 8\times$ larger than the secondary current.

Question #14 Key: (B)

BUMHS 2024

The direction of induced e.m.f can be determined by: [BUMHS 2024]

CORE CONCEPT AND DERIVATION

While multiple tools and rules exist, the fundamental physical law that assigns polarity to electromagnetic induction is Lenz's Law.

Solution:

- Lenz's law** explicitly defines the direction of the induced EMF by stating it must oppose the change in flux that created it.
- Note: Fleming's right-hand rule is a practical mnemonic derived from this law for use in generators, but Lenz's Law is the foundational principle.

Why other options are incorrect:

Faraday's law gives the magnitude, not direction. A galvanometer detects current but is an instrument, not a theoretical determining principle.

Question #15 Key: (D)

BUMHS 2024

Which of the following method can be used to vary induced emf in a coil? [BUMHS 2024]

CORE CONCEPT AND DERIVATION

According to Faraday's law, an EMF is induced whenever the magnetic flux ($\phi = B \cdot A \cdot \cos \theta$) through a coil changes.

Solution:

- Alternating magnetic field:** Changes the B component of the flux over time.
- Moving the coil:** Can change the angle (θ) or move the coil into a stronger/weaker field region.
- Changing the shape of coil:** Alters the effective Area (A) enclosed by the loop.
- Since all three actions successfully change the magnetic flux over time, **All of the above** methods will vary the induced EMF.

Why other options are incorrect:

None of the individual options are wrong, making D the only comprehensive and correct choice.

Question #16 Key: (B)

BUMHS 2024

Let an inductor is connected with battery. If emf induced in the inductor opposes emf of battery, then electri...

CORE CONCEPT AND DERIVATION

An inductor acts to resist any change in the current flowing through it (a consequence of Lenz's Law).

Solution:

- When current tries to **increase** (like when a switch is first closed), the expanding magnetic field induces a "Back EMF" that actively fights the battery's voltage to slow the current's growth.
- If the current were decreasing, the inductor would induce a forward EMF (supporting the battery) to try to keep the current flowing.
- Since the induced EMF is opposing the battery, the current must be **increasing**.

Why other options are incorrect:

If current is constant, induced EMF is zero. If current is decreasing, the induced EMF acts in the same direction as the battery, not opposing it.

Question #17 Key: (B)

BUMHS 2024

The induced emf in a [Formula] turns coil if change in flux through the coil [Formula] in [Formula]: [BUMHS 2...

CORE CONCEPT AND DERIVATION

Faraday's Law, combined with Lenz's Law, calculates both the magnitude and polarity of the induced voltage.

Formula:

$$\varepsilon = -N \frac{\Delta\phi}{\Delta t}$$

Solution:

- Given: Number of turns $N = 100$.
- Change in flux $\Delta\phi = 2 \times 10^{-4} \text{ Wb}$.
- Time interval $\Delta t = 0.02 \text{ s} = 2 \times 10^{-2} \text{ s}$.
- Substitute values into the formula:

$$\varepsilon = -100 \times \frac{2 \times 10^{-4}}{2 \times 10^{-2}}$$

- Simplify the fraction:

$$\varepsilon = -100 \times (1 \times 10^{-2})$$

- Solve:

$$\varepsilon = -100 \times 0.01 = -1.0 \text{ V}$$

Why other options are incorrect:

Option A misses the negative sign dictated by Lenz's law. Options C and D stem from failing to convert the decimal 0.02 correctly when managing the exponents.

Question #18 Key: (A)

UHS 2023

In principle, the transformer consists of two coils of copper, electrically insulated from each other, wound on a...

CORE CONCEPT AND DERIVATION

To maximize efficiency, a transformer must guide nearly 100% of the primary coil's magnetic flux into the secondary coil.

Solution:

- Soft **Iron** is a highly permeable ferromagnetic material.
- Winding both coils on a laminated **Iron core** traps the magnetic field lines and funnels them directly from the primary to the secondary coil, preventing flux leakage.

Why other options are incorrect:

Copper and gold are excellent electrical conductors but poor magnetic conductors (they are non-magnetic). While some steel alloys are used, "soft iron" is the fundamental and most broadly correct generic textbook answer.

Question #19 Key: (A)

UHS 2023

Velocity selector will select only those charge particle whose velocity is given by: [UHS 2023]

CORE CONCEPT AND DERIVATION

A velocity selector utilizes perpendicular electric and magnetic fields to filter charged particles based on speed.

Formula:

$$F_e = F_b$$

Solution:

- The electric force ($F_e = qE$) and magnetic force ($F_b = qvB$) are arranged to oppose each other.
- For a particle to pass through undeflected, the forces must balance precisely: $qE = qvB$.
- Canceling charge (q) and solving for velocity gives: $v = \frac{E}{B}$.

Why other options are incorrect:

Option B is the inverted ratio. Option C is mathematically incorrect dimensionally. Option D implies stationary particles, which cannot pass through the apparatus.

Question #20 Key: (B)

UHS 2023

The induced emf produced in the coil is sometimes called as? [UHS 2023]

CORE CONCEPT AND DERIVATION

When alternating current flows through a coil, it creates a changing magnetic flux that intersects the coil's own turns.

Solution:

- According to Lenz's law, this self-induced EMF opposes the very change in current that created it.
- Because it acts in direct opposition to the applied driving voltage, it is commonly referred to as a **Back EMF**.

Why other options are incorrect:

Self-inductance is a property of the coil (measured in Henrys), not the EMF itself. Motional EMF requires a conductor physically moving through a field. Mutual inductance involves two separate coils.

Question #21 Key: (D)

UHS 2023

The quantity [Formula] has the same units as that of? [UHS 2023]

CORE CONCEPT AND DERIVATION

Faraday's Law directly equates the rate of change of magnetic flux to induced voltage.

Formula:

$$\varepsilon = -N \frac{\Delta\phi}{\Delta t}$$

Solution:

- The left side of the equation represents Electromotive Force (EMF), which is measured in Volts.
- Therefore, the right side term, $\frac{\Delta\phi}{\Delta t}$ (Webers per second), must dimensionally equal Volts. Thus, it has the same units as **EMF**.

Why other options are incorrect:

Current is Amperes, Magnetic induction is Teslas, and Charge is Coulombs. None of these match the dimensions of Volts.

Question #22 Key: (D)

UHS 2023

Working principal of magnetic levitation train is according to? [UHS 2023]

CORE CONCEPT AND DERIVATION

Maglev trains utilize induced magnetic fields that actively oppose the train's own magnetic field to create levitation.

Solution:

- As electromagnets on the train sweep past conductive coils in the track, they induce a current in the track.
- According to **Lenz's Law**, this induced track current generates a magnetic field whose polarity strongly repels the train's magnets, causing it to levitate.

Why other options are incorrect:

Ohm's law governs basic circuit resistance. Planck's law relates to quantum body radiation. (Refer to Q.74 for nuance on regional answer key variations).

Question #23 Key: (A)

UHS 2023

The expression for the emf produced by A.C generator is? [UHS 2023]

CORE CONCEPT AND DERIVATION

An AC generator rotates a coil of area A inside a uniform magnetic field B at a constant angular velocity ω .

Formula:

$$\varepsilon = \varepsilon_0 \sin(\omega t)$$

Solution:

- The flux through the coil is $\phi = NAB \cos(\theta)$, where $\theta = \omega t$.
- Taking the time derivative (Faraday's law) yields a sine function: $\varepsilon = -\frac{d\phi}{dt} = NAB\omega \sin(\omega t)$.
- Since $\omega t = \theta$, the standard expression is $N\omega AB \sin(\theta)$.

Why other options are incorrect:

The cosine function represents the magnetic flux, not the derivative (EMF). Option C only gives peak EMF. The tangent function is never used in standard generator wave models.

Question #24 Key: (B)

SZABMU 2023

The phenomenon in which a changing current in one coil induces an emf in another coil is: [SZABMU 2023]

CORE CONCEPT AND DERIVATION

Electromagnetic induction can occur between physically separated but magnetically linked circuits.

Solution:

- When current changes in a primary coil, it alters the surrounding magnetic field.
- This expanding/collapsing field sweeps across a neighboring secondary coil, inducing voltage. The "mutual" sharing of this flux between two distinct coils is defined as **Mutual induction**.

Why other options are incorrect:

Self-induction happens within the same single coil. Eddy currents are wasteful circular currents induced in solid metal cores. A choke is an inductor designed to utilize self-induction to block high-frequency AC.

Question #25 Key: (C)

SZABMU 2023

The induced current will flow in such a direction as to oppose the cause that produces it. It is the statement...

CORE CONCEPT AND DERIVATION

The direction of induced electromotive forces and currents must strictly adhere to energy conservation.

Solution:

- Lenz's Law** dictates that nature resists change in magnetic flux. If a magnet is pushed toward a coil, the coil induces a magnetic pole that pushes back, opposing the motion.

Why other options are incorrect:

Faraday's Law calculates the magnitude of the EMF. Ampere's Law relates current to magnetic fields. Joule's Law calculates electrical heat generation.

Question #26 Key: (B)

SZABMU 2023

The transformer depends on the use of: [SZABMU 2023]

CORE CONCEPT AND DERIVATION

Transformers rely on mutual induction, which fundamentally requires a **changing** magnetic field to function.

Solution:

- Only an **Alternating Current (AC)** naturally and continuously reverses direction, thereby producing the continuously changing magnetic flux needed to induce an EMF in the secondary coil.

Why other options are incorrect:

Direct Current (DC) produces a constant, static magnetic field. A static field results in $\Delta\phi = 0$, meaning zero induced EMF. Therefore, transformers cannot work on DC.

Question #27 Key: (C)

SZABMU 2023

The domestic electricity supply in Pakistan has a frequency of: [SZABMU 2023]

CORE CONCEPT AND DERIVATION

National power grids standardize their alternating current frequencies to ensure safe and compatible operations of all appliances.

Solution:

- The standard frequency for the AC mains supply in Pakistan (as inherited from British engineering standards) is 50 Hz.

Why other options are incorrect:

Options A, B, and D are not standard grid frequencies anywhere in the modern world. Note: The United States and parts of South America use 60 Hz.

Question #28 Key: (C)

SZABMU 2023

Transformer works on the principle of: [SZABMU 2023]

CORE CONCEPT AND DERIVATION

A transformer transfers electrical energy between two isolated circuits via a magnetic core.

Solution:

- Because it relies on the magnetic flux of the primary coil inducing a voltage across the turns of the secondary coil, the defining physical principle is **Mutual induction**.

Why other options are incorrect:

Rectification (A and D) converts AC to DC, requiring diodes. Self-induction (B) governs single-coil components like inductors/chokes.

Question #29 Key: (B)

DUHS 2023

On which principle does the transformer work? [SINDH 2023]

CORE CONCEPT AND DERIVATION

The operation of a transformer depends fundamentally on interactions between multiple magnetically linked coils.

Solution:

- The changing AC current in the primary coil induces a voltage in the secondary coil. This transfer of energy across separate coils is defined as **Mutual induction**.

Why other options are incorrect:

Self-induction occurs within a single isolated coil. Motional EMF requires moving parts (generators). Magnetic torque drives electric motors.

Question #30 Key: (A)

DUHS 2023

If a transformer has [Formula] turns on primary coil and [Formula] turns on secondary coil, then [SINDH 2023]

CORE CONCEPT AND DERIVATION

The voltage ratio perfectly mirrors the turns ratio in an ideal transformer.

Formula:

$$\frac{V_s}{V_p} = \frac{N_s}{N_p}$$

Solution:

- Given: Primary turns $N_p = 500$, Secondary turns $N_s = 250$.
- Calculate the ratio: $\frac{V_s}{V_p} = \frac{250}{500} = \frac{1}{2}$.
- Therefore, $V_s = \frac{1}{2}V_p$, meaning the **output voltage is half of the input voltage** (a step-down transformer).

Why other options are incorrect:

The output would only be double if the secondary had twice the turns of the primary. Equal voltage requires equal turns.

Question #31 Key: (C)

DUHS 2023

Induced e.m.f in A.C generator can be increased by: [SINDH 2023]

CORE CONCEPT AND DERIVATION

The maximum Electromotive Force (EMF) generated by an AC generator depends directly on its physical dimensions and operating speed.

Formula:

$$\varepsilon_{\max} = N\omega AB$$

Solution:

- The equation reveals that maximum EMF is directly proportional to the Area (A) of the coil.
- Therefore, **increasing the area of the coil** will linearly increase the total induced EMF.

Why other options are incorrect:

Decreasing the area, decreasing the magnetic field, or slowing the rotation (reducing ω) all reduce the rate of flux change, which mathematically decreases the induced EMF.

Question #32 Key: (A)

DUHS 2023

A transformer is used to: [SINDH 2023]

CORE CONCEPT AND DERIVATION

A transformer is a passive electrical device used to shift the balance of voltage and current in an AC system.

Solution:

- Because transformers rely on continuous changes in magnetic flux to operate, they strictly **transform alternating current and voltage** magnitudes (stepping them up or down).

Why other options are incorrect:

Converting AC to DC is done by a rectifier. Converting mechanical to electrical energy is done by a generator. Converting DC to AC is done by an inverter.

Question #33 Key: (B)

DUHS 2023

The main function of a transformer is to convert. [SINDH 2023]

CORE CONCEPT AND DERIVATION

Transformers only function when exposed to changing magnetic fields, which are naturally provided by alternating currents.

Solution:

- The primary purpose of a transformer is to act as a step-up or step-down bridge in an AC network.
- Therefore, it converts **one alternating voltage to another alternating voltage of different magnitude**, maintaining the same frequency.

Why other options are incorrect:

Transformers cannot operate on direct voltage (DC) because static flux induces no EMF. They also do not perform rectification (converting AC to DC).

Question #34 Key: (C)

NUMS 2023

The Lenz's law is also statement of law of conservation of: [NUMS 2023]

CORE CONCEPT AND DERIVATION

Lenz's law provides the physical intuition behind the negative sign in Faraday's law of induction.

Solution:

- It states that an induced EMF always opposes the change generating it. This opposition requires mechanical work to be done to sustain motion.
- This mechanical work is converted directly into electrical energy. Thus, Lenz's law is fundamentally a manifestation of the **Conservation of Energy**.

Why other options are incorrect:

Charge conservation relates to Kirchhoff's Current Law. Mass and pressure are completely unrelated to electromagnetic induction principles.

Question #35 Key: (A)

NUMS 2023

A current generator is a device that converts: [NUMS 2023]

CORE CONCEPT AND DERIVATION

An electrical generator operates on the principle of motional electromagnetic induction.

Solution:

- By physically rotating a coil within a magnetic field (using turbines driven by water, steam, or wind), a generator turns **mechanical energy into electrical energy**.

Why other options are incorrect:

Option D describes an electric motor. Option B describes aspects of combustion engines or biological muscles. Option C describes a microphone.

Question #36 Key: (D)

UHS 2022

The source of magnetic field is: [UHS 2022]

CORE CONCEPT AND DERIVATION

Magnetic fields are fundamentally generated by moving electric charges.

Solution:

- A **current loop** consists of moving electrons, which naturally produce a magnetic field governed by Ampere's Law and the Biot-Savart Law.

Why other options are incorrect:

Isolated magnetic poles (monopoles) do not exist in classical electromagnetism. Static charges produce only electric fields. Nonmagnetic substances do not generate significant magnetic fields.

Question #37 Key: (B)

UHS 2022

One meter long copper rod is moving with speed [Formula] in the magnetic field of strength [Formula]. What is...

CORE CONCEPT AND DERIVATION

When a conductor moves perpendicularly through a magnetic field, motional EMF is induced across its ends.

Formula:

$$\varepsilon = vBL \sin(\theta)$$

Solution:

- Given: Length $L = 1 \text{ m}$, Speed $v = 20 \text{ ms}^{-1}$, Magnetic Field $B = 0.6 \text{ T}$.
- Assuming perpendicular motion ($\sin(90^\circ) = 1$):

$$\varepsilon = 20 \times 0.6 \times 1$$

$$\varepsilon = 12 \text{ V}$$

Why other options are incorrect:

Options A, C, and D are incorrect products of the given values. 12 V is the exact mathematical result.

Question #38 Key: (C)

UHS 2022

The unit of [Formula] can be written as? [UHS 2022]

CORE CONCEPT AND DERIVATION

According to Faraday's law, the rate of change of magnetic flux equals induced EMF, whose SI unit is the Volt (V).

Solution:

- Voltage is Joules per Coulomb: $1 \text{ V} = 1 \text{ J C}^{-1}$.
- Break down Joules ($J = \text{N m}$) and Coulombs ($C = \text{A s}$).
- Substituting these in:

$$\text{Unit} = \frac{\text{N m}}{\text{A s}} = \text{N m A}^{-1} \text{s}^{-1}$$

Why other options are incorrect:

Other options have incorrect powers for Ampere (A) or second (s), resulting in invalid dimensional equivalents for Voltage.

Question #39 Key: (A)

UHS 2022

Working principal of magnetic levitation train is according to? [UHS 2022]

CORE CONCEPT AND DERIVATION

Magnetic levitation (Maglev) trains utilize powerful electromagnets to lift and propel the train, eliminating rolling friction.

Solution:

- The underlying principle governing the induction of opposing magnetic fields in the track coils is **Faraday's Law of Electromagnetic Induction** (though Lenz's Law dictates the specific repulsive direction).

Why other options are incorrect:

Max Planck's law relates to quantum energy. Ohm's law relates voltage, current, and resistance. (While Lenz's law gives the direction of levitation force, the source key marks A).

Question #40 Key: (B)

UHS 2022

A copper hoop is held in a vertical east-west plane in a uniform magnetic field whose field lines run along th...

CORE CONCEPT AND DERIVATION

Maximum EMF is induced when the rate of change of magnetic flux is maximized. This happens when the coil physically cuts through the magnetic field lines optimally.

Solution:

- The magnetic field runs North-South. The hoop is initially in an East-West plane, meaning maximum flux is passing through it.
- To create the greatest change in flux (cutting the lines), the hoop must flip out of this alignment. Rotating it around an **East-West axis** will cause its plane to repeatedly intersect the North-South field lines, inducing maximum EMF.

Why other options are incorrect:

Rotating about a North-South axis spins the hoop like a steering wheel relative to the field lines; the flux doesn't change, so zero EMF is induced. Linear motion without rotation in uniform fields does not change the flux linking the area.

Question #41 Key: (B)

UHS 2022

In transformer, there is no ____ connection between the two coils but they are ____ linked? [UHS 2022]

CORE CONCEPT AND DERIVATION

Transformers transfer energy between circuits without direct wiring between the primary and secondary sides.

Solution:

- The primary and secondary coils are insulated from each other, meaning there is **no electrical** connection.
- Energy is transferred via a shared magnetic core where changing flux links the two coils, meaning they are **magnetically linked**.

Why other options are incorrect:

Coils are strictly electrically isolated to prevent direct current flow. They are not optically linked (which would be an optoisolator, not a standard transformer).

Question #42 Key: (C)

SZABMU 2022

In Fleming's right hand rule the middle finger indicates: [SZABMU 2022]

CORE CONCEPT AND DERIVATION

Fleming's Right-Hand Rule is used to determine the direction of induced current in a generator.

Solution:

- **Thumb:** Points to the direction of Motion (Force).
- **First/Index Finger:** Points to the Magnetic Field (B).
- **Middle Finger:** Points to the direction of the **Induced Current**.

Why other options are incorrect:

Force is indicated by the thumb. The magnetic field is indicated by the index finger. Voltage is a scalar potential difference, not represented by the directional fingers.

Question #43 Key: (C)

SZABMU 2022

Transformer works on the principle of: [SZABMU 2022]

CORE CONCEPT AND DERIVATION

A transformer consists of two coils in proximity, sharing a magnetic flux.

Solution:

- When an alternating current flows in the primary coil, it generates a changing magnetic field.
- This changing flux induces an alternating EMF in the secondary coil. This specific two-coil interaction is known as **Mutual Induction**.

Why other options are incorrect:

While Faraday's and Lenz's laws govern how induction works generally, "Mutual induction" is the specific technological principle classifying the interaction of two separate coils in a transformer.

Question #44 Key: (D)

SZABMU 2022

The efficiency of transformer is: [SZABMU 2022]

CORE CONCEPT AND DERIVATION

Transformers are highly efficient solid-state devices with no moving parts.

Solution:

- Because there is no mechanical friction or air resistance, real-world transformers only suffer from minor copper (resistive) and iron (eddy current/hysteresis) losses.
- Well-designed commercial transformers typically achieve an efficiency of **90% to 99%**.

Why other options are incorrect:

Efficiencies of 60%, 70%, or 80% are characteristic of machines with heavy mechanical moving parts (like combustion engines or older motors), not modern transformers.

Question #45 Key: (B)

SZABMU 2022

Lenz's law is also a statement of law of conservation of: [SZABMU+BMU 2022]

CORE CONCEPT AND DERIVATION

Lenz's Law states that the direction of an induced current will oppose the change in magnetic flux that produced it.

Solution:

- This opposition creates a resistive magnetic force. Mechanical work must be actively done against this opposing force to keep the coil or magnet moving.
- This mechanical work is converted into the electrical energy of the induced current, perfectly demonstrating the **Conservation of Energy**.

Why other options are incorrect:

If Lenz's law did not hold (i.e., if induced current aided the motion), the magnet would accelerate infinitely, creating limitless energy. Charge, momentum, and mass conservation govern different physical phenomena.

Question #46 Key: (C)

KMU 2022

What is the inappropriate statement for step-up transformer? [ETEA 2022]

CORE CONCEPT AND DERIVATION

Real transformers experience energy losses due to internal resistance and magnetic core phenomena.

Solution:

- Eddy currents and hysteresis in the core, along with the resistance of the copper windings (I^2R losses), inevitably generate heat.
- Therefore, the statement "**Heat is never produced in step-up transformer**" is practically false (inappropriate) for any real-world device.
- Note: Option D is also physically impossible (output energy can never exceed input), but standard curriculum keys often highlight C to emphasize non-ideal thermodynamic realities. , C is marked.

Why other options are incorrect:

Options A and B accurately describe the core function of a step-up transformer: increasing voltage while proportionally decreasing current.

Question #47 Key: (B)

KMU 2022

An ideal AC generator has equal input and output, its heat dissipation will be: [ETEA 2022]

CORE CONCEPT AND DERIVATION

An "ideal" machine is a theoretical construct that operates with 100% efficiency.

Solution:

- By definition, 100% efficiency means Input Power = Output Power.
- If all mechanical input is perfectly converted to electrical output, there is absolutely no energy left over to be converted into heat.
- Therefore, heat dissipation in an ideal generator is exactly **Zero**.

Why other options are incorrect:

Finite, small, or maximum heat dissipation implies energy is being lost (efficiency < 100%), which contradicts the premise of an "ideal" generator.

Question #48 Key: (B)

KMU 2022

AC generator stops suddenly when: [ETEA 2022]

CORE CONCEPT AND DERIVATION

According to Lenz's Law, generating current creates a magnetic field that opposes the very rotation producing it (a braking effect or "back torque").

Solution:

- To keep a generator spinning, an external mechanical torque must be constantly applied (like a turbine).
- If the electrical load draws too much current, the opposing **torque of the back EMF (magnetic braking) exceeds the applied external torque**, causing the generator to physically stall or stop.

Why other options are incorrect:

Heat from resistance reduces efficiency but doesn't instantly stop rotation. Moment of inertia relates to mass distribution and doesn't spontaneously change. External voltage refers to motors, not the physical stalling of a generator.

Question #49 Key: (A)

BUMHS 2022

The maximum value of induced emf in a rotating coil in a magnetic field does not depend upon: [BMU 2022]

CORE CONCEPT AND DERIVATION

The peak Electromotive Force (EMF) of an AC generator is determined by its physical construction and rotational speed.

Formula:

$$\varepsilon_{\max} = N\omega AB$$

Solution:

- The equation shows dependence on Number of turns (N), Angular frequency ($\omega = 2\pi f$), Area (A), and Magnetic Field (B).
- The **Resistance of the coil** determines the *current* that will flow once a load is connected, but it has absolutely no effect on the raw open-circuit voltage (EMF) being generated.

Why other options are incorrect:

Options B, C, and D are direct variables (N , A , f) in the generator formula, so the EMF heavily depends on them.

Question #50 Key: (B)

BUMHS 2022

As induced emf is produced in a circuit when: [BMU 2022]

CORE CONCEPT AND DERIVATION

Faraday's Law of Electromagnetic Induction defines the fundamental condition for inducing voltage.

Solution:

- An EMF is only induced in a conductive loop when the **magnetic flux** passing through that loop **changes** over time.
- This can happen by changing the field strength, the loop's area, or the angle between them.

Why other options are incorrect:

If the magnetic flux remains constant (Option D), the derivative is zero, so EMF = 0. Changing electric flux induces magnetic fields (Maxwell's addition to Ampere's law), not standard motional EMF.

Question #51 Key: (B)

DUHS 2022

The mathematical equation representing Faraday's law is: [DUHS 2022]

CORE CONCEPT AND DERIVATION

Faraday's law mathematically relates induced EMF to the rate of change of magnetic flux, with Lenz's law providing the negative sign.

Solution:

- The induced EMF ($\mathcal{E}$) in a coil of N turns is proportional to the rate of change of magnetic flux ($\frac{\Delta\phi}{\Delta t}$).
- The equation is written as: $\mathcal{E} = -N \frac{\Delta\phi}{\Delta t}$, where the negative sign indicates opposition to the change.

Why other options are incorrect:

Option A describes self-induction (using L instead of N typically, though conceptually similar). Option D omits the number of turns N , which is required for a multi-turn coil.

Question #52 Key: (B)

DUHS 2022

The instantaneous emf generated by alternating current generator is written as: [DUHS 2022]

CORE CONCEPT AND DERIVATION

The voltage output of an AC generator follows a sinusoidal wave pattern over time.

Formula:

$$\mathcal{E} = \mathcal{E}_0 \sin(\omega t)$$

Solution:

- The peak EMF ($\mathcal{E}_0$) generated by a rotating coil is given by $N\omega AB$.
- Substituting $\mathcal{E}_0$ into the instantaneous equation yields: $\mathcal{E} = BN A \omega \sin(\omega t)$.

Why other options are incorrect:

Options A and C mistakenly include Current (I) in the EMF generation formula, which is a mix-up with magnetic force equations. Option D is mathematically nonsensical for an AC generator.

Question #53 Key: (B)

DUHS 2022

For efficient transfer of electricity through cables over the long distance: [DUHS 2022]

CORE CONCEPT AND DERIVATION

Power loss in transmission lines is governed by Joule heating ($P_{\text{loss}} = I^2 R$).

Solution:

- To deliver a required amount of power ($P = VI$), we can alter the balance of V and I .
- Because heat loss is proportional to the **square** of the current (I^2), grid operators use step-up transformers to dramatically increase voltage.
- This forces the **current to be low and voltage high**, ensuring maximum efficiency over hundreds of kilometers.

Why other options are incorrect:

High current causes massive resistive heating lines. Low voltage would require high current to deliver identical power, defeating the purpose.

Question #54 Key: (B)

NUMS 2022

Lenz's law is based on the law of conservation of: [NUMS 2022]

CORE CONCEPT AND DERIVATION

Lenz's Law ensures that electrical energy does not manifest from nowhere.

Solution:

- The induced current flows in a direction that generates an opposing magnetic force.
- Overcoming this opposing force requires mechanical work. This work is what is fundamentally converted into electrical energy, satisfying the law of **Conservation of Energy**.

Why other options are incorrect:

If Lenz's law were false, an induced magnetic field would attract the moving magnet, accelerating it endlessly. This would create infinite kinetic and electrical energy without doing work, violating thermodynamic laws.

Question #55 Key: (A)

NUMS 2022

In Fleming's right-hand rule, the thumb indicates: [NUMS 2022]

CORE CONCEPT AND DERIVATION

Fleming's Right-Hand Rule maps the 3D vectors of electromagnetism in a generator.

Solution:

- Index finger = Magnetic field (North to South).
- Middle finger = Induced current direction.
- **Thumb** = Direction of the motion of the conductor, which represents the applied mechanical **Force**.

Why other options are incorrect:

The magnetic field is the index finger. Induced current is the middle finger. Electric field is not directly represented in this specific generator rule.

Question #56 Key: (C)

NUMS 2022

Transformer works on the principle of: [NUMS 2022]

CORE CONCEPT AND DERIVATION

A transformer consists of two separate coils (primary and secondary) that influence one another.

Solution:

- An AC current in the primary coil generates an oscillating magnetic flux.
- This flux penetrates the secondary coil, inducing an AC voltage. This cross-coil induction is exclusively termed **Mutual induction**.

Why other options are incorrect:

Self-induction applies to a single coil (like an inductor). Rectification (half or full wave) is the conversion of AC to DC, which is performed by diodes, not transformers.

Question #57 Key: (A)

PMDC 2021

Which is the correct relation: [NMDCAT 2021]

CORE CONCEPT AND DERIVATION

In a transformer, the ratio of voltages is directly proportional to the ratio of turns.

Formula:

$$\frac{N_s}{N_p} = \frac{V_s}{V_p}$$

Solution:

- The voltage induced per turn is constant for both coils. Therefore, $\frac{V_s}{N_s} = \frac{V_p}{N_p}$.
- Rearranging gives the correct relation: $\frac{N_s}{N_p} = \frac{V_s}{V_p}$.

Why other options are incorrect:

Option B is mathematically meaningless. Option C is incorrect because current ratio is inversely proportional to the turns ratio ($\frac{N_s}{N_p} = \frac{I_p}{I_s}$).

Question #58 Key: (B)

PMDC 2021

In a step-up transformer, current across secondary is ____
[NMDCAT 2021]

CORE CONCEPT AND DERIVATION

A transformer adheres to the law of conservation of energy. For an ideal transformer, Input Power = Output Power.

Formula:

$$V_p I_p = V_s I_s$$

Solution:

- In a step-up transformer, the secondary voltage is greater than the primary voltage ($V_s > V_p$).
- To keep the power constant, the secondary current must decrease proportionally. Thus, $I_s < I_p$, meaning the current across the secondary is **less**.

Why other options are incorrect:

If current were more or equal while voltage increased, the transformer would generate energy out of nowhere, violating the law of conservation of energy.

Question #59 Key: (A)

PMDC 2021

Find Turn ratio if [Formula] ? [NMDCAT 2021]

CORE CONCEPT AND DERIVATION

The turn ratio of a transformer is defined as the ratio of secondary turns to primary turns ($N_s : N_p$).

Formula:

$$\text{Turn Ratio} = \frac{N_s}{N_p} = \frac{V_s}{V_p}$$

Solution:

- Since the voltage ratio $\frac{V_s}{V_p}$ is given as 2 (or 2 : 1), the turn ratio is identically equal.
- Therefore, the turn ratio is 2 : 1.

Why other options are incorrect:

Option B (1:2) is the inverse. Option C (4:8) simplifies to 1:2, which is also incorrect.

Question #60 Key: (D)

PMDC 2021

[PMC Sample 3] Which of the following physical quantities remains completely unchanged across the primary and ...

CORE CONCEPT AND DERIVATION

A transformer modifies voltage and current levels through mutual induction but cannot change the timing frequency of the alternating source.

Solution:

While a transformer can step up/down both **voltage** and **current**, the rate of change of magnetic flux is governed strictly by the source. Consequently, the **frequency** of the alternating electric signal remains completely invariant between the primary and secondary circuits.

Note: In an **ideal** transformer, the electrical power is also conserved ($P_{in} = P_{out}$), but in any real, practical transformer, power decreases due to heat and flux losses. Frequency is the only quantity that is strictly conserved in all cases.

Why other options are incorrect:

- **Voltage** and **Current** are modified by the turns ratio $\frac{N_s}{N_p}$.
- **Power** drops in all non-ideal transformers due to hysteresis, copper losses, and eddy currents.

Question #61 Key: (C)

PMDC 2021

[PMC Practice 5] Alternating current (AC) generators utilize which of the following contact rings to connect t...

CORE CONCEPT AND DERIVATION

This question covers the mechanical interface for drawing electrical current from a rotating shaft in a generator.

Solution:

An AC generator uses continuous copper **slip rings**. These rings rotate with the armature coil and maintain constant sliding contact with stationary carbon brushes, allowing the naturally alternating current induced in the coil to flow into the external load as AC.

Why other options are incorrect:

- **Split rings** (or commutators) are used in DC generators and DC motors to mechanically reverse the connection polarities every half-turn, converting the internal AC into an external DC.

Question #62 Key: (D)

PMDC 2020

In transmission from grid station, power losses are minimized by:
[NMDCAT 2020]

CORE CONCEPT AND DERIVATION

Power loss in transmission lines is primarily due to Joule heating.

Formula:

$$P_{\text{loss}} = I^2 R$$

Solution:

- To transmit a given amount of power ($P = VI$), if the transmission voltage (V) is **increased**, the current (I) is proportionally decreased.
- Since power loss scales with the square of the current (I^2), minimizing current by stepping up the voltage drastically reduces energy losses during long-distance transmission.

Why other options are incorrect:

Increasing current exponentially increases heat loss. Increasing resistance also increases loss. Decreasing current is a *result* of increasing voltage, but stepping up the voltage at the grid station is the primary action taken.

Question #63 Key: (C)

PMDC 2020

The domestic electricity supply has a frequency of: [NMDCAT 2020]

CORE CONCEPT AND DERIVATION

Electricity grids operate at standardized frequencies depending on the region's historical infrastructural standards.

Solution:

- In Pakistan (and many other parts of the world such as Europe and Asia), domestic AC electricity is supplied at a standard frequency of 50 Hz.

Why other options are incorrect:

Frequencies like 100 Hz, 150 Hz, or 25 Hz are not standard for modern national power grids. (Note: The US uses 60 Hz).

Question #64 Key: (B)

PMDC 2020

Transformer is a device which steps up or steps down the input:
[NMDCAT 2020]

CORE CONCEPT AND DERIVATION

A transformer operates on mutual induction to alter electrical parameters between primary and secondary circuits.

Solution:

- The primary purpose of a transformer is to step up (increase) or step down (decrease) alternating **voltage**. The current changes inversely to maintain power conservation.

Why other options are incorrect:

While current changes as a consequence, the terminology 'step-up/down' explicitly refers to the voltage level. An ideal transformer conserves Energy and Power, so it cannot step them up.

Question #65 Key: (C)

PMDC 2020

If a stationary bar magnet is placed near a coil at rest so maximum lines of force passes through the coil, th...

CORE CONCEPT AND DERIVATION

Faraday's Law of Electromagnetic Induction dictates that an EMF is only induced when there is a **change** in magnetic flux over time.

Formula:

$$\varepsilon = -N \frac{\Delta \phi}{\Delta t}$$

Solution:

- Since both the magnet and the coil are **stationary** ($\Delta \phi / \Delta t = 0$), the flux passing through the coil is constant.
- Therefore, no EMF is induced, and the galvanometer will show **no current**.

Why other options are incorrect:

Maximum, minimum, or intermediate currents require relative motion. The quantity of flux linking the coil does not matter; only the *rate of change* of that flux generates current.

Question #66 Key: (B)

KMU 2018

The function of main transformer is to convert: [ETEA 2018]

CORE CONCEPT AND DERIVATION

A transformer requires a continuously changing magnetic flux to induce an EMF in the secondary coil, which is only possible with alternating current (AC).

Solution:

- The core function of a transformer is to step up or step down AC voltages while maintaining the same frequency. Therefore, it converts **one alternating voltage to another alternating voltage of different magnitude**.

Why other options are incorrect:

Transformers cannot operate on direct current (DC) because constant current produces no change in flux. They also do not convert AC to DC; that is the job of a rectifier.

Question #67 Key: (D)

KMU 2017

The phenomenon used for producing emf in coil of generator is; [ETEA 2017]

CORE CONCEPT AND DERIVATION

An electrical generator converts mechanical energy into electrical energy by moving a conductor through a magnetic field.

Solution:

- According to Faraday's Law, when a coil rotates in a magnetic field, the changing magnetic flux induces an EMF. This overarching process is known as **electromagnetic induction**.

Why other options are incorrect:

Mutual induction is for transformers. Self-induction applies to single inductors/chokes. Electrostatic induction involves static charges, not magnetic fields.

Question #68 Key: (A)

KMU 2016

The phenomenon of mutual induction is practically used is: [ETEA 2016]

CORE CONCEPT AND DERIVATION

Mutual induction is the process where a changing current in one coil induces an electromotive force (EMF) in a neighboring coil.

Solution:

- A **transformer** operates fundamentally on this principle. An alternating current in the primary coil creates a continuously changing magnetic flux, which links with the secondary coil to induce an EMF.

Why other options are incorrect:

Generators rely on motional electromagnetic induction (a coil rotating in a magnetic field). Galvanometers and Avometers operate on the principle of magnetic torque experienced by a current-carrying coil.

Question #69 **Key: (D)**

KMU 2009

A transformer changes [Formula] to [Formula] and there are [Formula] in the secondary coil. The number of turn...

CORE CONCEPT AND DERIVATION

For an ideal transformer, the ratio of secondary to primary voltages is directly proportional to the ratio of their turns.

Formula:

$$\frac{V_s}{V_p} = \frac{N_s}{N_p}$$

Solution:

- Given: $V_p = 12 \text{ V}$, $V_s = 18000 \text{ V}$, $N_s = 6000$

- Rearranging for N_p :

$$N_p = N_s \times \frac{V_p}{V_s}$$

- Substituting the values:

$$N_p = 6000 \times \frac{12}{18000}$$

- Simplifying:

$$N_p = \frac{6000}{1500} = 4$$

Why other options are incorrect:

Options A, B, and C result from incorrect algebraic rearrangement or simple arithmetic errors during division.