

**PHY · PHYSICS**

12. Alternating Current

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

🕒 54 Solved Questions

📅 2006 to 2025 Archive

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

📖 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.**

BUMHS 2025

If the capacitance in a purely capacitive AC circuit is doubled, the current will be:

- (A) Double
- (B) Become half
- (C) Remain same
- (D) Decrease to the fourth

Q2.

SZABMU 2025

A capacitor is connected to an ac source. If the frequency of the AC source is doubled the current in a purely capacitive circuit will:

- (A) Remains Unchanged
- (B) Be doubled
- (C) Become Half
- (D) Becomes zero

Q3.

DUHS 2025

If frequency of AC is doubled, the inductive reactance will:

- (A) Remain same
- (B) Be halved
- (C) Be doubled
- (D) Become zero.

Q4.

KMU 2025

In a pure capacitance AC circuit, the current:

- (A) Lags behind voltage by 90°
- (B) Is in phase with the voltage
- (C) Leads the voltage by 45°
- (D) Leads the voltage by 90°

Q5.

KMU 2025

The wave that has the highest frequency and penetrating power is:

- (A) Gamma rays
- (B) X-rays
- (C) Ultraviolet rays
- (D) Microwaves

Q6.

NUMS 2025

Which electromagnetic wave is used to kill bacteria and insects in food?

- (A) Beta rays
- (B) UV rays
- (C) Alpha rays
- (D) Gamma Rays

Q7.

PMDC 2022

A simple AC generator consists of how many magnetic poles?

- (A) 0
- (B) 1
- (C) 2
- (D) 3

Q8.

PMDC 2021

[PMC Practice 8]

If the peak voltage of an AC signal is 9 V, the corresponding peak-to-peak voltage of the waveform is:

- (A) 9 V
- (B) 18 V
- (C) 4.5 V
- (D) 0 V

Q9.

PMDC 2021

[PMC Practice 28]

The time duration required to complete one entire cycle of an alternating quantity is defined as the:

- (A) Period
- (B) Cycle
- (C) Instantaneous value
- (D) Sine wave

Q10.

PMDC 2021

[PMC Practice 28]

The duration of one complete wave cycle of alternating current is known as its:

- (A) Instantaneous value
- (B) Period
- (C) Frequency
- (D) Phase

Q11.

PMDC 2021

[PMC 2021 Tested]

Which of the following types of radiation is an electromagnetic wave and therefore requires **NO** material medium to propagate?

- (A) Alpha rays
- (B) Beta rays
- (C) Gamma rays
- (D) All of these

Q12.

PMDC 2021

[PMC 2021 Tested]

The narrow spectral region that lies between the Infrared (IR) and Ultraviolet (UV) regions of the electromagnetic spectrum is called:

- (A) Radio waves
- (B) X-ray region
- (C) Visible light
- (D) None of these

Q13.

PMDC 2021

[PMC Practice 33]

The ozone layer in the upper atmosphere protects life on Earth by absorbing and scattering which type of radiation from the sun?

- (A) Infrared (IR)
- (B) Alpha radiation
- (C) Ultraviolet (UV)
- (D) All of these

Q14.

PMDC 2021

[PMC Test 1]

Energy emitted in the form of visible radiation is called:

- (A) Geothermal energy
- (B) Light energy
- (C) Sound energy
- (D) Tidal energy

Q15.

PMDC 2021

[PMC 2021 Tested]

Microwaves are best classified as ____ waves.

- (A) Longitudinal and mechanical
- (B) Longitudinal and electromagnetic
- (C) Transverse and electromagnetic
- (D) Transverse and mechanical

Q16.

KMU 2019

[ETEA 2019]

Which of the following is **NOT** an electromagnetic wave?

- (A) Radio waves
- (B) X-rays
- (C) Sound waves
- (D) Light waves

Q17.

NUMS 2019

In an AC circuit containing only a pure inductor, what is the phase relationship between voltage and current?

- (A) Current leads voltage by 90°
- (B) Voltage leads current by 90°
- (C) Voltage and current are in phase
- (D) Voltage lags current by 180°

Q18.

KMU 2017

[ETEA 2017]

Which of the following arrangements correctly orders the regions of the electromagnetic spectrum in terms of decreasing wavelength (longest to shortest)?

- (A) Infrared > Ultraviolet > Visible > Microwave > Radio frequency
- (B) Radio frequency > Microwave > Infrared > Visible > Ultraviolet
- (C) Microwave > Infrared > Visible > Ultraviolet > Radio frequency
- (D) Visible > Infrared > Ultraviolet > Microwave > Radio frequency

Q19.

KMU 2016

A.C and D.C have the same:

- (A) Effect in charging battery
- (B) Effect in charging capacitor
- (C) Heating effect through a resistance
- (D) Effect passing through an inductance

Q20.

KMU 2016

In purely resistive circuit the current _____.

- (A) Leads voltage by one half of a cycle
- (B) Leads voltage by one fourth of a cycle
- (C) Leads voltage by one and a half of a cycle
- (D) Is in phase with voltage

Q21.

KMU 2016

Which of the following electromagnetic rays has the smallest wavelength?

- (A) X-rays
- (B) Gamma rays
- (C) Microwaves
- (D) Ultraviolet rays

Q22.

KMU 2016

The potential difference and the current flowing through a component in an A.C. circuit are given by:

$$V = 5 \cos \omega t \text{ volts}$$

$$i = 2 \sin \omega t \text{ amperes}$$

The power dissipated in the instrument is:

- (A) Zero Watt
- (B) 10 Watt
- (C) 5 Watt
- (D) 2.5 Watt

Q23.

KMU 2016

The potential difference and the current flowing through a component in an A.C. circuit are given by:

$$V = 3 \cos \omega t \text{ V}$$

$$i = 4 \sin \omega t \text{ A}$$

The circuit is:

- (A) A capacitive circuit
- (B) An inductive circuit
- (C) A resistive Circuit
- (D) Can be any of these

Q24.

KMU 2016

In pure inductance, the average power dissipated is:

- (A) 1W
- (B) Greater than 1W
- (C) Less than 1W
- (D) Zero

Q25.

KMU 2016

A $35 \mu\text{F}$ capacitor is connected to a source of sinusoidal e.m.f with a frequency of 400 Hz and a maximum e.m.f of 20 V. The maximum current is:

- (A) 0 A
- (B) 0.28 A
- (C) 1.8 A
- (D) 230 A

Q26.

KMU 2016

Which of the following are also called heat radiations?

- (A) Visible light
- (B) Radio waves
- (C) Microwaves
- (D) Infrared rays

Q27.

KMU 2016

The changing electric flux in a certain region of space produces:

- (A) An electric field
- (B) A magnetic field
- (C) Both electric and magnetic fields
- (D) None of the above

Q28.

NUMS 2015

[NUMS 2015]

An A.C. emf of $E = 100 \sin(100\pi t)$ volt is connected across a choke of negligible resistance. In order to produce a current of amplitude 1 A, the inductance of the choke should be:

- (A) 200 H
- (B) 2π H
- (C) $1/\pi$ H
- (D) $2/\pi$ H

Q29.

NUMS 2015

[NUMS 2015]

In a series RLC circuit at resonance, the AC voltages across the Resistance R , Inductance L , and Capacitance C are 5 V, 10 V, and 10 V respectively. The AC voltage applied to the circuit will be:

- (A) 25 V
- (B) 10 V
- (C) 5 V
- (D) 20 V

Q30.

KMU 2015

The instantaneous value of e.m.f at time t is $V = 20 \sin(100\pi t)$. The frequency of the alternating quantity is:

- (A) 100 Hz
- (B) 50 Hz
- (C) 25 Hz
- (D) 20 Hz

Q31.

KMU 2015

An A.C current varies with time (t) sec as $i = 4 \sin(200\pi t)$, the r.m.s value of current in ampere is:

- (A) 2 A
- (B) $4\sqrt{2}$ A
- (C) $\frac{2}{\sqrt{2}}$ A
- (D) $2\sqrt{2}$ A

Q32.

KMU 2015

Phase angle between voltage and current in A.C through a pure inductor is:

- (A) 0°
- (B) 90°
- (C) 60°
- (D) 180°

Q33.

KMU 2015

Peak value of alternating current is $5\sqrt{2}$ A. The mean square value of current will be:

- (A) 5 A
- (B) 25 A^2
- (C) $5\sqrt{2}$ A
- (D) 50 A^2

Q34.

KMU 2015

Which of the following is the smoothest waveform?

- (A) Sinusoidal waveform
- (B) Triangular waveform
- (C) Saw-tooth shape waveform
- (D) Rectangular waveform

Q35.

KMU 2015

At what frequency will a 1 H inductor have a reactance of 500Ω ?

- (A) 80 Hz
- (B) 60 Hz
- (C) 40 Hz
- (D) 20 Hz

Q36.

KMU 2015

An alternating voltage $\varepsilon = 200 \sin(100t)$ is connected to a $1 \mu\text{F}$ capacitor through an A.C. ammeter. The peak reading of current shall be:

- (A) 10 mA
- (B) 80 mA
- (C) 20 mA
- (D) 40 mA

Q37.

KMU 2015

The slope of the graph between inductive reactance and the frequency of an A.C source is related to:

- (A) Impedance
- (B) Resistance
- (C) Power factor
- (D) Inductance

Q38.

KMU 2015

Which of the following is not an electromagnetic radiation?

- (A) X-rays
- (B) UV rays
- (C) Cathode rays
- (D) Infrared rays

Q39.

KMU 2015

For the production of electromagnetic waves, the electric charges must be:

- (A) Stationary charges
- (B) Charges moving with uniform velocity
- (C) Accelerating charges
- (D) All of these

Q40.

KMU 2015

The current which is produced due to changing electric flux is called:

- (A) Displacement current
- (B) Conduction current
- (C) Eddy current
- (D) None of these

Q41.

KMU 2015

For electromagnetic waves, Maxwell generalized which of the following laws?

- (A) Gauss's law for magnetism
- (B) Gauss's law for electricity
- (C) Faraday's law
- (D) Ampere's law

Q42.

KMU 2012

The sinusoidal AC current in a circuit is $i = 50 \sin(20t)$. The peak value of current is:

- (A) 100 A
- (B) 25 A
- (C) 50 A
- (D) 20 A

Q43.

KMU 2012

An alternating current is represented by the equation $i = i_0 \sin \omega t$. Which one of the following equations represents an alternating current that has half the amplitude and double the frequency:

- (A) $i = 2i_0 \sin \omega t$
- (B) $2i = i_0 \sin^{-1} \omega t$
- (C) $i = \frac{1}{2}i_0 \sin 2\omega t$
- (D) $2i = i_0 \sin \omega t$

Q44.

KMU 2012

An alternating current of r.m.s 20 mA passes through a $4 \text{ k}\Omega$ resistor. What is the average power dissipated?

- (A) 0.8 W
- (B) 1.6 W
- (C) $8 \times 10^8 \text{ W}$
- (D) $1.6 \times 10^8 \text{ W}$

Q45.

KMU 2011

The sinusoidal alternating voltage can be expressed by the equation $V = V_m \cos \omega t$. The instantaneous value of alternating voltage at $t = 3T/4$ is:

- (A) V_m
- (B) $-V_m$
- (C) Zero
- (D) None of these

Q46.

KMU 2010

In alternating current the average value of current in a cycle is:

- (A) Zero
- (B) Constant
- (C) Positive
- (D) Maximum

Q47.

KMU 2010

The r.m.s value of alternating voltage for unit peak amplitude ($V_0 = 1 \text{ V}$) is:

- (A) 1.77 volt
- (B) 17.7 volt
- (C) 0.707 volt
- (D) 0.0177 volt

Q48.

KMU 2010

The capacitive reactance of the AC circuit increases:

- (A) By increasing the frequency of AC
- (B) By decreasing the frequency of AC
- (C) Does not depend upon the frequency of AC voltage
- (D) None of these

Q49.

KMU 2009

Which of the following has least wavelength?

- (A) α -rays
- (B) Cosmic rays
- (C) β -rays
- (D) X-rays

Q50.

KMU 2009

The average power loss in a capacitor in an AC circuit is:

- (A) $\langle P \rangle = V_0 I_0$
- (B) $\langle P \rangle = V_0 I_0 \sin \omega t$
- (C) $\langle P \rangle = V_0 I_0 \cos \omega t$
- (D) $\langle P \rangle = \text{Zero}$

Q51.

KMU 2007

The alternating current can be measured from its:

- (A) Magnetic effect
- (B) Heating effect
- (C) Chemical effect
- (D) All of these

Q52.

KMU 2007

Which of the following has the highest energy photon?

- (A) Visible light
- (B) X-rays
- (C) Ultraviolet rays
- (D) Gamma rays

Q53.

KMU 2006

In a capacitive circuit, current and voltage phase relation is:

- (A) In-phase
- (B) Current leads voltage by 90°
- (C) Voltage leads current by 90°
- (D) Current leads voltage by 180°

Q54.

KMU 2006

The mean square value of the alternating current is:

- (A) $i_{\text{ms}} = i_0^2/2$
- (B) $i_{\text{ms}} = i_0^2/\sqrt{2}$
- (C) $i_{\text{ms}} = 2i_0^2$
- (D) $i_{\text{ms}} = \sqrt{2}i_0^2$

RAPID 5–COLUMN ANSWER KEY

Official PMDC verified answer keys for 12. Alternating Current.

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Q#	KEY	BOARD	Q#	KEY	BOARD	Q#	KEY	BOARD	Q#	KEY	BOARD	Q#	KEY	BOARD
1	A	BUMHS 2025	12	C	PMDC 2021	23	B	KMU 2016	34	A	KMU 2015	45	C	KMU 2011
2	B	SZABMU 2025	13	C	PMDC 2021	24	D	KMU 2016	35	A	KMU 2015	46	A	KMU 2010
3	C	DUHS 2025	14	B	PMDC 2021	25	C	KMU 2016	36	C	KMU 2015	47	C	KMU 2010
4	D	KMU 2025	15	C	PMDC 2021	26	D	KMU 2016	37	D	KMU 2015	48	B	KMU 2010
5	A	KMU 2025	16	C	KMU 2019	27	B	KMU 2016	38	C	KMU 2015	49	B	KMU 2009
6	D	NUMS 2025	17	B	NUMS 2019	28	C	NUMS 2015	39	C	KMU 2015	50	D	KMU 2009
7	C	PMDC 2022	18	B	KMU 2017	29	C	NUMS 2015	40	A	KMU 2015	51	B	KMU 2007
8	B	PMDC 2021	19	C	KMU 2016	30	B	KMU 2015	41	D	KMU 2015	52	D	KMU 2007
9	A	PMDC 2021	20	D	KMU 2016	31	D	KMU 2015	42	C	KMU 2012	53	B	KMU 2006
10	B	PMDC 2021	21	B	KMU 2016	32	B	KMU 2015	43	C	KMU 2012	54	A	KMU 2006
11	C	PMDC 2021	22	A	KMU 2016	33	B	KMU 2015	44	B	KMU 2012			

TOTAL
MCQS

54

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: (A)

BUMHS 2025

If the capacitance in a purely capacitive AC circuit is doubled, the current will be:

CORE CONCEPT AND DERIVATION

In an AC circuit containing a pure capacitor, alternating current is inversely proportional to capacitive reactance and directly proportional to capacitance.

Formula / Reaction:

$$I = \frac{V}{X_C} = 2\pi fCV$$

Solution:

- Capacitive reactance is defined as $X_C = \frac{1}{2\pi fC}$.
- Substituting X_C into the current equation gives $I = \frac{V}{X_C} = 2\pi fCV$.
- Because current is directly proportional to capacitance ($I \propto C$), doubling the capacitance ($C' = 2C$) results in doubling the current ($I' = 2I$).

Why other options are incorrect:

Because current increases in direct proportion to capacitance ($I \propto C$), it cannot be halved, remain unchanged, or decrease to one-fourth.

Question #2 Key: (B)

SZABMU 2025

A capacitor is connected to an ac source. If the frequency of the AC source is doubled the current in a purely...

CORE CONCEPT AND DERIVATION

In a purely capacitive AC circuit, the alternating current is directly proportional to the supply frequency because capacitive reactance decreases as frequency rises.

Formula / Reaction:

$$I = \frac{V}{X_C} = 2\pi fCV$$

Solution:

- The reactance of a capacitor is given by $X_C = \frac{1}{2\pi fC}$.
- The alternating current is $I = \frac{V}{X_C} = V(2\pi fC) = 2\pi fCV$.
- Since $I \propto f$, doubling the source frequency ($f' = 2f$) directly doubles the current in the circuit ($I' = 2I$).

Why other options are incorrect:

Increasing frequency reduces capacitive opposition to current flow; hence, current cannot remain unchanged, halve, or drop to zero.

Question #3 Key: (C)

DUHS 2025

If frequency of AC is doubled, the inductive reactance will:

CORE CONCEPT AND DERIVATION

Inductive reactance is the opposition offered by an inductor to the flow of alternating current, and it is directly proportional to the frequency of the AC source.

Formula / Reaction:

$$X_L = 2\pi fL$$

Solution:

- Inductive reactance is expressed by the relation $X_L = 2\pi fL$.
- For a given inductor of fixed inductance L , $X_L \propto f$.
- When the AC frequency is doubled ($f' = 2f$), the inductive reactance doubles accordingly ($X'_L = 2X_L$).

Why other options are incorrect:

Since X_L is directly proportional to frequency, doubling f doubles X_L ; it cannot remain constant, reduce by half, or become zero.

Question #4 Key: (D)

KMU 2025

In a pure capacitance AC circuit, the current:

CORE CONCEPT AND DERIVATION

In a purely capacitive AC circuit, the alternating current leads the alternating voltage across the capacitor by a phase angle of 90° ($\frac{\pi}{2}$ rad).

Formula / Reaction:

$$q = CV \implies I = \frac{\Delta q}{\Delta t}$$

Solution:

- When an alternating voltage $V = V_0 \sin(\omega t)$ is applied across a capacitor, the instantaneous current is $I = I_0 \cos(\omega t) = I_0 \sin(\omega t + \frac{\pi}{2})$.
- The rate of change of charge (and hence current) reaches its maximum when the voltage is zero.
- Therefore, current leads the alternating voltage by a phase difference of 90° (or $\frac{\pi}{2}$ rad).

Why other options are incorrect:

Current lagging behind voltage by 90° occurs in purely inductive circuits; current in-phase with voltage occurs in purely resistive circuits; a 45° phase angle occurs only in series RC circuits where $R = X_C$.

Question #5 Key: (A)

KMU 2025

The wave that has the highest frequency and penetrating power is:

CORE CONCEPT AND DERIVATION

In the electromagnetic spectrum, photon energy and penetrating power increase directly with frequency and inversely with wavelength.

Formula / Reaction:

$$E = hf = \frac{hc}{\lambda}$$

Solution:

- The electromagnetic spectrum ordered by increasing frequency is: Radio waves < Microwaves < Infrared < Visible light < Ultraviolet < X-rays < Gamma rays.
- Gamma rays have the shortest wavelengths ($\lambda < 10^{-11}$ m) and highest frequencies ($f > 10^{19}$ Hz).
- Because photon energy is directly proportional to frequency ($E = hf$), Gamma rays carry the highest energy per quantum and have the greatest penetrating power.

Why other options are incorrect:

X-rays, Ultraviolet rays, and Microwaves possess longer wavelengths, lower frequencies, and lower photon energies than Gamma rays, giving them significantly lower penetrating power.

Question #6 Key: (D)

NUMS 2025

Which electromagnetic wave is used to kill bacteria and insects in food?

CORE CONCEPT AND DERIVATION

Food irradiation utilizes highly penetrating ionizing electromagnetic radiation to neutralize pathogens, bacteria, and pests without raising the temperature of food.

Formula / Reaction:

Qualitative concept / No formula required.

Solution:

- Gamma rays are high-energy electromagnetic waves emitted by radioisotopes (such as Cobalt-60).
- Due to their high penetrating capability, gamma rays pass completely through packaged food items and disrupt the cellular DNA of bacteria, parasites, and insects.
- This sterilizes the food, retards spoilage, and extends shelf life safely.

Why other options are incorrect:

Alpha rays (helium nuclei) and Beta rays (high-speed electrons) are particulate radiations with extremely low penetration depth; UV rays are non-ionizing electromagnetic radiation that only disinfect surface layers.

Question #7 **Key: (C)**

PMDC 2022

A simple AC generator consists of how many magnetic poles?

CORE CONCEPT AND DERIVATION

An elementary AC generator requires a magnetic dipole to provide a uniform magnetic field across the rotating armature coil.

Formula / Reaction:

$$\Phi = BA \cos(\omega t), \quad \varepsilon = -N \frac{d\Phi}{dt} = NBA\omega \sin(\omega t)$$

Solution:

- A standard basic generator consists of at least one pair of magnetic poles: a North pole and a South pole (2 poles).
- Magnetic field lines pass from the North to South pole across the armature.

Why other options are incorrect:

- **Opt_A:** Magnetic fields cannot exist without poles.
- **Opt_B:** Isolated magnetic monopoles do not exist in nature.
- **Opt_D:** Magnetic poles always occur in conjugate pairs (even numbers: 2, 4, 6...).

Question #8 **Key: (B)**

PMDC 2021

[PMC Practice 8] If the peak voltage of an AC signal is [Formula], the corresponding peak-to-peak voltage of ...

CORE CONCEPT AND DERIVATION

This covers the conversion between peak voltage (amplitude) and peak-to-peak voltage for a symmetric alternating wave.

Formula:

$$V_{p-p} = 2V_p$$

Solution:

Given $V_p = 9 \text{ V}$:

$$V_{p-p} = 2 \times 9 \text{ V} = 18 \text{ V}$$

Why other options are incorrect:

- **4.5 V** is the result of dividing by 2 instead of multiplying.
- **9 V** is simply the peak amplitude.

Question #9 **Key: (A)**

PMDC 2021

[PMC Practice 28] The time duration required to complete one entire cycle of an alternating quantity is define...

CORE CONCEPT AND DERIVATION

This is a definition-based question covering basic parameters of alternating current theory.

Solution:

The **Time Period** (or simply period, T) is defined as the precise duration in seconds required for an alternating signal to complete one full cycle of positive and negative values.

Why other options are incorrect:

- **Cycle** is the physical repeating unit itself, not its duration.
- **Instantaneous value** is the value of voltage or current at any specific split second of time.

Question #10 Key: (B)

PMDC 2021

[PMC Practice 28] The duration of one complete wave cycle of alternating current is known as its:

CORE CONCEPT AND DERIVATION

This is a duplicate test question with a modified option arrangement to ensure consistency.

Solution:

The time taken for an alternating wave to complete one full cycle is called its **period**.

Why other options are incorrect:

- This matches the core definition of the waveform period, rendering other choices incorrect.

Question #11 Key: (C)

PMDC 2021

[PMC 2021 Tested] Which of the following types of radiation is an electromagnetic wave and therefore requires ...

CORE CONCEPT AND DERIVATION

Electromagnetic waves consist of self-propagating electric and magnetic fields, allowing them to travel through a vacuum without a supporting physical medium.

Solution:

- Gamma rays** are high-energy photons located at the short-wavelength end of the electromagnetic spectrum. Because they are electromagnetic waves, they require no physical medium to propagate.
- Alpha rays** (helium nuclei) and **Beta rays** (high-speed electrons or positrons) are streams of physical particles with mass and charge. They are matter streams, not electromagnetic waves.

Why other options are incorrect:

- Alpha and Beta rays are matter waves/streams that carry mass, so they are not electromagnetic waves and do not propagate in the same manner.

Question #12 Key: (C)

PMDC 2021

[PMC 2021 Tested] The narrow spectral region that lies between the Infrared (IR) and Ultraviolet (UV) regions ...

CORE CONCEPT AND DERIVATION

The electromagnetic spectrum is classified into bands based on wavelength and frequency.

Solution:

The **visible light** band occupies the narrow range of wavelengths from approximately 400 nm to 700 nm. This band is positioned directly between the longer-wavelength Infrared (IR) band and the shorter-wavelength Ultraviolet (UV) band.

Why other options are incorrect:

- X-rays** lie at shorter wavelengths beyond the UV band.
- Radio waves** lie at longer wavelengths beyond the IR band.

Question #13 Key: (C)

PMDC 2021

[PMC Practice 33] The ozone layer in the upper atmosphere protects life on Earth by absorbing and scattering w...

CORE CONCEPT AND DERIVATION

The ozone layer acts as a protective shield in the Earth's stratosphere.

Solution:

The **ozone layer** absorbs a significant portion (97% to 99%) of the high-energy, harmful **ultraviolet (UV)** radiation emitted by the sun, particularly UV-B and UV-C rays. This protection prevents skin cancer and ecological damage.

Why other options are incorrect:

- Ozone does not significantly absorb **Infrared** (heat) radiation or **Alpha** particles (which are absorbed by the upper atmosphere long before reaching the stratosphere).

Question #14 Key: (B)

PMDC 2021

[PMC Test 1] Energy emitted in the form of visible radiation is called:

CORE CONCEPT AND DERIVATION

Visible radiation is a portion of the electromagnetic spectrum that can be detected by the human eye.

Solution:

The electromagnetic energy emitted in the form of visible radiation is defined as **light energy**. It allows us to see objects and travels through a vacuum in the form of photons at the speed of light.

Why other options are incorrect:

- **Sound energy** is mechanical vibrational energy and is not electromagnetic or visible.
- **Geothermal** and **Tidal** energy are mechanical and thermal energy forms harvested from natural planetary forces, not visible electromagnetic emissions.

Question #15 Key: (C)

PMDC 2021

[PMC 2021 Tested] Microwaves are best classified as ____ waves.

CORE CONCEPT AND DERIVATION

Electromagnetic waves consist of electric and magnetic fields that vibrate perpendicular to the direction of wave travel.

Solution:

Microwaves belong to the electromagnetic spectrum, making them **electromagnetic** waves.

Because their oscillating electric and magnetic field vectors are oriented perpendicular to each other and perpendicular to the direction of propagation, they are also classified as **transverse** waves. Therefore, they are both **transverse and electromagnetic**.

Why other options are incorrect:

- Options containing **longitudinal** or **mechanical** are incorrect because microwaves do not vibrate parallel to their direction of propagation and do not require a physical material medium to travel.

Question #16 Key: (C)

KMU 2019

[ETEA 2019] Which of the following is NOT an electromagnetic wave?

CORE CONCEPT AND DERIVATION

This question distinguishes between electromagnetic waves and mechanical waves.

Solution:

Sound waves are mechanical waves. They consist of pressure fluctuations (compressions and rarefactions) in a physical medium and require a material medium (like air, water, or solids) to travel. They cannot travel through a vacuum.

Radio waves, X-rays, and visible light waves are all electromagnetic waves made of oscillating electric and magnetic fields, so they can travel through a vacuum.

Why other options are incorrect:

- Radio waves, X-rays, and light waves are all classified as electromagnetic waves because they consist of fluctuating electric and magnetic fields.

Question #17 Key: (B)

NUMS 2019

In an AC circuit containing only a pure inductor, what is the phase relationship between voltage and current?

CORE CONCEPT AND DERIVATION

In an inductor, back-EMF opposes rapid current changes. The voltage across the inductor peaks a quarter-cycle before the current.

Formula / Reaction:

$$v_L(t) = V_0 \sin(\omega t), \quad i(t) = I_0 \sin\left(\omega t - \frac{\pi}{2}\right)$$

Solution:

- Self-induction causes current to lag voltage by 90° .
- Equivalently, the voltage across the inductor leads current by 90° ($\pi/2$ rad).

Why other options are incorrect:

- **Opt_A:** Current leads voltage by 90° in a pure capacitor.
- **Opt_C:** Voltage and current are in phase in a pure resistor.
- **Opt_D:** A 180° lag represents complete phase opposition.

Question #18 Key: (B)

KMU 2017

[ETEA 2017] Which of the following arrangements correctly orders the regions of the electromagnetic spectrum i...

CORE CONCEPT AND DERIVATION

This question requires organizing the electromagnetic spectrum by wavelength from longest to shortest.

Solution:

Wavelength (λ) is inversely proportional to frequency. The correct order from longest wavelength (lowest frequency) to shortest wavelength (highest frequency) is:

Radio frequency > Microwave > Infrared > Visible Light > Ultraviolet

Why other options are incorrect:

- Other options place shorter wavelength bands (like ultraviolet or visible light) before longer wavelength bands (like microwave or infrared), violating the order of decreasing wavelength.

Question #19 Key: (C)

KMU 2016

A.C and D.C have the same:

CORE CONCEPT AND DERIVATION

The root mean square (RMS) value of alternating current is defined strictly by the thermal Joule heating effect in a pure resistor, which is independent of current direction.

Formula / Reaction:

$$H = I_{\text{rms}}^2 R t = I_{\text{DC}}^2 R t$$

Solution:

- Joule's heating law states $P = I^2 R$. Because current is squared, heat dissipation is always positive regardless of instantaneous polarity.
- An AC of root-mean-square value I_{rms} produces the exact same average thermal power in a resistor as a steady DC of magnitude $I_{\text{DC}} = I_{\text{rms}}$.

Why other options are incorrect:

- Opt_A:** Battery charging relies on chemical electrolysis, which requires unidirectional DC. AC produces zero net chemical deposition over a cycle.
- Opt_B:** DC charges a capacitor to a constant state and then stops, whereas AC continuously charges and discharges it.
- Opt_D:** An inductor opposes AC via inductive reactance $X_L = 2\pi fL$, but offers zero reactance to steady DC.

Question #20 **Key: (D)**

KMU 2016

In purely resistive circuit the current _____.

CORE CONCEPT AND DERIVATION

In an AC circuit containing only a pure ohmic resistor, the opposition to current flow is constant and does not depend on time or rate of change of current.

Formula / Reaction:

$$v = V_0 \sin(\omega t), \quad i = \frac{v}{R} = \frac{V_0}{R} \sin(\omega t) = I_0 \sin(\omega t)$$

Solution:

- Both voltage and current waveforms cross zero, increase, and reach their positive and negative maximums at the exact same instants.
- The phase difference $\phi = 0^\circ$, meaning current and voltage are strictly in-phase.

Why other options are incorrect:

- Opt_A:** Leading by one-half cycle corresponds to $\phi = 180^\circ$.
- Opt_B:** Leading by one-fourth cycle corresponds to $\phi = 90^\circ$, which occurs in a pure capacitor.
- Opt_C:** Leading by 1.5 cycles corresponds to 540° .

Question #21 **Key: (B)**

KMU 2016

Which of the following electromagnetic rays has the smallest wavelength?

CORE CONCEPT AND DERIVATION

Across the electromagnetic spectrum, wavelength decreases as photon energy and frequency increase.

Formula / Reaction:

$$\lambda_\gamma < \lambda_{X\text{-ray}} < \lambda_{UV} < \lambda_{\text{Visible}} < \lambda_{IR} < \lambda_{\text{Micro}} < \lambda_{\text{Radio}}$$

Solution:

- Gamma rays have the highest frequencies ($> 10^{19}$ Hz) and the shortest wavelengths ($\lambda < 10^{-11}$ m or < 0.01 nm).
- Therefore, gamma rays have the smallest wavelength among all electromagnetic waves.

Why other options are incorrect:

- Opt_A:** X-rays have wavelengths around 0.01 nm to 10 nm, which are longer than gamma rays.
- Opt_C:** Microwaves have long wavelengths (1 mm to 1 m).
- Opt_D:** Ultraviolet rays have wavelengths between 10 nm and 400 nm.

Question #22 **Key: (A)**

KMU 2016

The potential difference and the current flowing through a component in an A.C. circuit are given by: [Formula...]

CORE CONCEPT AND DERIVATION

Average real power in an AC circuit depends on the cosine of the phase angle difference ϕ between voltage and current.

Formula / Reaction:

$$P = V_{\text{rms}} I_{\text{rms}} \cos \phi$$

Solution:

- Using $\cos(\omega t) = \sin\left(\omega t + \frac{\pi}{2}\right)$, the voltage equation becomes $V = 5 \sin\left(\omega t + \frac{\pi}{2}\right)$.
- Current is $i = 2 \sin(\omega t)$.
- The phase difference is $\phi = 90^\circ$ ($\pi/2$ rad).
- $P = V_{\text{rms}} I_{\text{rms}} \cos(90^\circ) = 0 \text{ W}$.

Why other options are incorrect:

- **Opt_B:** 10 W is the product of peak values $V_0 I_0$ assuming $\cos \phi = 1$.
- **Opt_C:** 5 W is $\frac{1}{2} V_0 I_0$, valid only for in-phase waveforms.
- **Opt_D:** 2.5 W is an incorrect fraction.

Question #23 **Key: (B)**

KMU 2016

The potential difference and the current flowing through a component in an A.C. circuit are given by: [Formula...]

CORE CONCEPT AND DERIVATION

Rewriting both quantities as sine functions reveals their relative phase angle. If voltage leads current by 90° , the circuit is purely inductive.

Formula / Reaction:

$$V = 3 \cos(\omega t) = 3 \sin\left(\omega t + \frac{\pi}{2}\right), \quad i = 4 \sin(\omega t)$$

Solution:

- Comparing phases: Voltage phase is $\omega t + \pi/2$ and current phase is ωt .
- Voltage leads current by $\frac{\pi}{2}$ (90°).
- A 90° voltage lead is the characteristic signature of an inductive circuit.

Why other options are incorrect:

- **Opt_A:** In a capacitive circuit, current leads voltage by 90° .
- **Opt_C:** In a resistive circuit, voltage and current are in-phase.
- **Opt_D:** The phase relationship uniquely identifies an inductive circuit.

Question #24 **Key: (D)**

KMU 2016

In pure inductance, the average power dissipated is:

CORE CONCEPT AND DERIVATION

In an ideal inductor, the current lags the applied voltage by 90° .
No electrical energy is converted into heat.

Formula / Reaction:

$$P = V_{\text{rms}} I_{\text{rms}} \cos(90^\circ) = 0$$

Solution:

- Energy is stored in the magnetic field during the first quarter-cycle and completely returned to the source during the next quarter-cycle.
- Therefore, the net average power dissipated over any complete cycle is identically zero.

Why other options are incorrect:

- **Opt_A, Opt_B, Opt_C:** Non-zero values are incorrect because ideal inductors do not dissipate real power.

Question #25 **Key: (C)**

KMU 2016

A [Formula] capacitor is connected to a source of sinusoidal e.m.f with a frequency of [Formula] and a maximum...

CORE CONCEPT AND DERIVATION

Peak current through a capacitor is determined by peak voltage divided by capacitive reactance: $I_0 = \omega C V_0 = 2\pi f C V_0$.

Formula / Reaction:

$$I_0 = 2\pi f C V_0$$

Solution:

- Given: $f = 400 \text{ Hz}$, $C = 35 \times 10^{-6} \text{ F}$, $V_0 = 20 \text{ V}$.
- $I_0 = 2 \times 3.1416 \times 400 \times (35 \times 10^{-6}) \times 20$.
- $I_0 = 2 \times 3.1416 \times 400 \times 700 \times 10^{-6} = 2 \times 3.1416 \times 0.28 \approx 1.76 \text{ A} \approx 1.8 \text{ A}$.

Why other options are incorrect:

- **Opt_A:** Current is non-zero in an active AC circuit.
- **Opt_B:** 0.28 A misses multiplying by 2π .
- **Opt_D:** Calculation error.

Question #26 **Key: (D)**

KMU 2016

Which of the following are also called heat radiations?

CORE CONCEPT AND DERIVATION

Infrared radiation is readily absorbed by molecular vibrational modes in matter, causing an increase in thermal kinetic energy and temperature.

Formula / Reaction:

$$\lambda_{\text{IR}} \approx 700 \text{ nm to } 1 \text{ mm}$$

Solution:

- Warm objects emit electromagnetic radiation predominantly in the infrared band.
- Because its absorption produces noticeable heating in objects and biological tissue, infrared radiation is commonly termed heat radiation.

Why other options are incorrect:

- **Opt_A:** Visible light stimulates human vision.
- **Opt_B:** Radio waves are used for communication.
- **Opt_C:** Microwaves are used in radar and dielectric heating.

Question #27 **Key: (B)**

KMU 2016

The changing electric flux in a certain region of space produces:

CORE CONCEPT AND DERIVATION

According to the Maxwell-Ampere law, a time-varying electric field acts as a source of a magnetic field.

Formula / Reaction:

$$\oint \vec{B} \cdot d\vec{l} = \mu_0 I_C + \mu_0 \epsilon_0 \frac{d\Phi_E}{dt}$$

Solution:

- A changing electric flux $\frac{d\Phi_E}{dt}$ induces a magnetic field $\vec{B}$ in the surrounding space, forming the foundation of electromagnetic wave propagation.

Why other options are incorrect:

- **Opt_A:** A changing magnetic flux produces an electric field (Faraday's law), not a changing electric flux.
- **Opt_C:** The direct entity generated by changing electric flux is a magnetic field.
- **Opt_D:** Option B is correct.

Question #28 Key: (C)

NUMS 2015

[NUMS 2015] An A.C. emf of [Formula] volt is connected across a choke of negligible resistance. In order to pr...

CORE CONCEPT AND DERIVATION

A choke is an inductor designed to limit AC current. For a purely inductive circuit, the opposition to the alternating current is called inductive reactance.

Formula:

The inductive reactance is defined as:

$$X_L = \omega L$$

and the current amplitude (peak current) is:

$$I_0 = \frac{E_0}{X_L}$$

Solution:

Compare the given voltage equation $E = 100 \sin(100\pi t)$ to the standard equation $E = E_0 \sin(\omega t)$:

- Peak EMF, $E_0 = 100$ V
- Angular frequency, $\omega = 100\pi$ rad/s
- Peak current, $I_0 = 1$ A

Substitute these values to solve for inductance L :

$$I_0 = \frac{E_0}{\omega L} \Rightarrow 1 = \frac{100}{100\pi \times L}$$

$$L = \frac{100}{100\pi} = \frac{1}{\pi} \text{ H}$$

Why other options are incorrect:

- Other options like 200 H, 2π H, or $2/\pi$ H are incorrect due to standard errors in algebraic rearrangement, such as multiplying by 2 instead of dividing or incorrect cancellation of 100.

Question #29 Key: (C)

NUMS 2015

[NUMS 2015] In a series RLC circuit at resonance, the AC voltages across the Resistance [Formula], Inductance...

CORE CONCEPT AND DERIVATION

In a series RLC circuit, AC voltages must be added vectorially (as phasors) rather than algebraically because of the phase differences between them.

Formula:

The total source voltage V is:

$$V = \sqrt{V_R^2 + (V_L - V_C)^2}$$

Solution:

Given information:

- $V_R = 5$ V
- $V_L = 10$ V
- $V_C = 10$ V

At the resonance condition, the inductive reactance matches the capacitive reactance, which means the voltages across them are equal and in exact phase opposition (180° out of phase):

$$V = \sqrt{5^2 + (10 - 10)^2} = \sqrt{5^2 + 0} = 5 \text{ V}$$

The total applied voltage is simply equal to the voltage drop across the resistor.

Why other options are incorrect:

- **20 V** and **25 V** result from simple algebraic addition (e.g., $5 + 10 + 10 = 25$ V), which completely ignores phase vector alignment.
- **10 V** is the value of the reactive components alone.

Question #30 **Key: (B)**

KMU 2015

The instantaneous value of e.m.f at time t is [Formula]. The frequency of the alternating quantity is:

CORE CONCEPT AND DERIVATION

The time-dependent sinusoidal voltage equation relates the argument of the sine function to angular frequency $\omega = 2\pi f$.

Formula / Reaction:

$$V = V_0 \sin(2\pi ft)$$

Solution:

- Given: $V = 20 \sin(100\pi t)$.
- Comparing coefficients: $\omega = 2\pi f = 100\pi$.
- Solving for frequency: $f = \frac{100\pi}{2\pi} = 50 \text{ Hz}$.

Why other options are incorrect:

- Opt_A:** 100 Hz incorrectly takes ω/π instead of $\omega/2\pi$.
- Opt_C:** 25 Hz results from dividing by 4π .
- Opt_D:** 20 V is the peak voltage V_0 , not the frequency.

Question #31 **Key: (D)**

KMU 2015

An A.C current varies with time (t) sec as [Formula], the r.m.s value of current in ampere is:

CORE CONCEPT AND DERIVATION

The root mean square (RMS) current of a sinusoidal wave is related to the peak current by $I_{\text{rms}} = \frac{I_0}{\sqrt{2}}$.

Formula / Reaction:

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

Solution:

- From the equation $i = 4 \sin(200\pi t)$, peak current $I_0 = 4 \text{ A}$.
- $I_{\text{rms}} = \frac{4}{\sqrt{2}} = \frac{2 \times 2}{\sqrt{2}} = 2\sqrt{2} \text{ A}$.

Why other options are incorrect:

- Opt_A:** 2 A incorrectly divides I_0 by 2 instead of $\sqrt{2}$.
- Opt_B:** Multiplies I_0 by $\sqrt{2}$ instead of dividing.
- Opt_C:** While $4/\sqrt{2}$ is mathematically equivalent to $2\sqrt{2}$, the simplified textbook form $2\sqrt{2}$ is the standard final answer.

Question #32 **Key: (B)**

KMU 2015

Phase angle between voltage and current in A.C through a pure inductor is:

CORE CONCEPT AND DERIVATION

In a pure inductor, Faraday's law of electromagnetic induction generates a self-induced back emf $e = -L \frac{di}{dt}$ that opposes changes in current.

Formula / Reaction:

$$v_L(t) = L \frac{di}{dt} \Rightarrow v_L = V_0 \sin\left(\omega t + \frac{\pi}{2}\right)$$

Solution:

- Voltage reaches its peak when the rate of change of current is maximum (at $i = 0$).
- Thus, alternating voltage leads the alternating current by 90° ($\pi/2$ rad), or current lags voltage by 90° .

Why other options are incorrect:

- **Opt_A:** 0° phase angle occurs in a pure resistor.
- **Opt_C:** 60° occurs in combination circuits containing both resistance and reactance.
- **Opt_D:** 180° represents complete phase inversion.

Question #33 **Key: (B)**

KMU 2015

Peak value of alternating current is [Formula]. The mean square value of current will be:

CORE CONCEPT AND DERIVATION

The mean square value of an alternating current waveform is half of the square of its peak value.

Formula / Reaction:

$$\langle I^2 \rangle = \frac{I_0^2}{2}$$

Solution:

- Given peak current: $I_0 = 5\sqrt{2}$ A.
- $I_0^2 = (5\sqrt{2})^2 = 25 \times 2 = 50 \text{ A}^2$.
- $\langle I^2 \rangle = \frac{50}{2} = 25 \text{ A}^2$.

Why other options are incorrect:

- **Opt_A:** 5 A is the RMS value ($I_{\text{rms}} = \sqrt{25} = 5$ A), not the mean square value.
- **Opt_C:** $5\sqrt{2}$ A is the peak current I_0 .
- **Opt_D:** 50 A^2 is the peak square I_0^2 , without dividing by 2.

Question #34 **Key: (A)**

KMU 2015

Which of the following is the smoothest waveform?

CORE CONCEPT AND DERIVATION

A pure sinusoidal wave consists of a single, continuous harmonic frequency without higher-order harmonic distortions or sharp discontinuities.

Formula / Reaction:

$$y(t) = A \sin(\omega t)$$

Solution:

- Square, triangular, and saw-tooth waves contain sharp corners and infinite series of higher-frequency odd/even harmonics (Fourier components).
- A sine wave has a perfectly smooth, infinitely differentiable mathematical profile containing zero harmonic distortion, making it the smoothest AC waveform.

Why other options are incorrect:

- **Opt_B:** Triangular waveforms have sharp periodic slope reversals.
- **Opt_C:** Saw-tooth waveforms have discontinuous vertical drop-offs.
- **Opt_D:** Rectangular waveforms have instantaneous step discontinuities.

Question #35 **Key: (A)**

KMU 2015

At what frequency will a [Formula] inductor have a reactance of [Formula]?

CORE CONCEPT AND DERIVATION

Inductive reactance is related to frequency and inductance by $X_L = 2\pi fL$.

Formula / Reaction:

$$f = \frac{X_L}{2\pi L}$$

Solution:

- Given: $X_L = 500 \, \Omega$ and $L = 1 \, \text{H}$.
- $f = \frac{500}{2\pi(1)} = \frac{250}{\pi} \approx \frac{250}{3.1416} \approx 79.6 \, \text{Hz} \approx 80 \, \text{Hz}$.

Why other options are incorrect:

- **Opt_B:** 60 Hz gives $X_L \approx 377 \, \Omega$.
- **Opt_C:** 40 Hz gives $X_L \approx 251 \, \Omega$.
- **Opt_D:** 20 Hz gives $X_L \approx 126 \, \Omega$.

Question #36 Key: (C)

KMU 2015

An alternating voltage [Formula] is connected to a [Formula] capacitor through an A.C. ammeter. The peak readi...

CORE CONCEPT AND DERIVATION

The peak current through a pure capacitor is given by $I_0 = \frac{V_0}{X_C} = \omega C V_0$.

Formula / Reaction:

$$I_0 = \omega C V_0$$

Solution:

- From $\varepsilon = 200 \sin(100t)$: $V_0 = 200$ V and $\omega = 100$ rad/s.
- Given: $C = 1 \mu\text{F} = 1 \times 10^{-6}$ F.
- $I_0 = (100)(1 \times 10^{-6})(200) = 2 \times 10^{-2}$ A = 20 mA.

Why other options are incorrect:

- **Opt_A:** 10 mA uses $V_0 = 100$ V.
- **Opt_B:** 80 mA is an incorrect arithmetic scaling.
- **Opt_D:** 40 mA results from doubling the voltage.

Question #37 Key: (D)

KMU 2015

The slope of the graph between inductive reactance and the frequency of an A.C source is related to:

CORE CONCEPT AND DERIVATION

Inductive reactance is a linear function of frequency: $X_L = (2\pi L)f$. Plotting X_L versus f produces a straight line through the origin with slope proportional to inductance.

Formula / Reaction:

$$X_L = (2\pi L)f \implies \text{Slope} = \frac{\Delta X_L}{\Delta f} = 2\pi L$$

Solution:

- The gradient of the $X_L - f$ graph is $2\pi L$.
- Dividing the slope by the constant 2π gives the self-inductance L of the coil.

Why other options are incorrect:

- **Opt_A:** Impedance is total opposition in combination circuits.
- **Opt_B:** Resistance is independent of frequency.
- **Opt_C:** Power factor is a dimensionless ratio.

Question #38 **Key: (C)**

KMU 2015

Which of the following is not an electromagnetic radiation?

CORE CONCEPT AND DERIVATION

Electromagnetic radiations are massless photons propagating at the speed of light. Cathode rays are streams of material particles (electrons).

Formula / Reaction:

Cathode rays = beam of electrons ($m_e = 9.11 \times 10^{-31} \text{ kg}$, $q = -e$)

Solution:

- Cathode rays possess mass, carry negative electric charge, and are deflected by electrostatic and magnetic fields.
- X-rays, UV rays, and infrared rays are uncharged, massless electromagnetic waves.

Why other options are incorrect:

- **Opt_A, Opt_B, Opt_D:** All are standard regions of the electromagnetic spectrum.

Question #39 **Key: (C)**

KMU 2015

For the production of electromagnetic waves, the electric charges must be:

CORE CONCEPT AND DERIVATION

Stationary charges produce static electric fields, charges in uniform motion produce steady magnetic fields, and accelerated charges radiate electromagnetic energy.

Formula / Reaction:

$$a = \frac{dv}{dt} \neq 0 \implies \text{Electromagnetic radiation}$$

Solution:

- An accelerating charge creates time-varying electric and magnetic fields that propagate outward as electromagnetic waves.

Why other options are incorrect:

- **Opt_A:** Stationary charges produce only electrostatic fields.
- **Opt_B:** Uniform motion produces constant magnetic fields without radiation.
- **Opt_D:** Only accelerated charges radiate.

Question #40 **Key: (A)**

KMU 2015

The current which is produced due to changing electric flux is called:

CORE CONCEPT AND DERIVATION

Maxwell introduced displacement current to account for time-varying electric fields producing magnetic fields, ensuring Ampere's Law satisfies charge conservation.

Formula / Reaction:

$$I_D = \epsilon_0 \frac{d\Phi_E}{dt}$$

Solution:

- The rate of change of electric flux between capacitor plates produces a displacement current I_D that generates a magnetic field just like a conduction current.

Why other options are incorrect:

- **Opt_B:** Conduction current is the actual drift of physical charges through a conductor ($I = dq/dt$).
- **Opt_C:** Eddy currents are closed loops of induced conduction current circulating inside bulk conductors.
- **Opt_D:** Option A is correct.

Question #41 **Key: (D)**

KMU 2015

For electromagnetic waves, Maxwell generalized which of the following laws?

CORE CONCEPT AND DERIVATION

Ampere's original circuital law was incomplete for non-steady currents. Maxwell added the displacement current term $\epsilon_0 \frac{d\Phi_E}{dt}$.

Formula / Reaction:

$$\oint \vec{B} \cdot d\vec{l} = \mu_0 \left(I + \epsilon_0 \frac{d\Phi_E}{dt} \right)$$

Solution:

- Maxwell generalized Ampere's Law by incorporating the displacement current, making the equations symmetric and predicting the existence of electromagnetic waves.

Why other options are incorrect:

- **Opt_A, Opt_B:** Gauss's laws describe static field divergences.
- **Opt_C:** Faraday formulated electromagnetic induction, which Maxwell adopted directly.

Question #42 **Key: (C)**

KMU 2012

The sinusoidal AC current in a circuit is [Formula]. The peak value of current is:

CORE CONCEPT AND DERIVATION

The instantaneous alternating current is modeled by the standard sinusoidal equation $i = I_0 \sin(\omega t)$, where I_0 represents the peak amplitude.

Formula / Reaction:

$$i(t) = I_0 \sin(\omega t)$$

Solution:

- Comparing $i = 50 \sin(20t)$ directly with the standard equation $i = I_0 \sin(\omega t)$:
- Peak current $I_0 = 50$ A.
- Angular frequency $\omega = 20$ rad/s.

Why other options are incorrect:

- **Opt_A:** 100 A represents the peak-to-peak value $2I_0$, not the peak value.
- **Opt_B:** 25 A is half of the peak current.
- **Opt_D:** 20 rad/s is the angular frequency ω , not the current amplitude.

Question #43 **Key: (C)**

KMU 2012

An alternating current is represented by the equation [Formula]. Which one of the following equations represe...

CORE CONCEPT AND DERIVATION

The general equation for a sinusoidal AC is $i(t) = I_{\text{new}} \sin(\omega_{\text{new}} t)$, where I_{new} is the amplitude and ω_{new} is the angular frequency.

Formula / Reaction:

$$I_{\text{new}} = \frac{i_0}{2}, \quad \omega_{\text{new}} = 2\omega \implies i = \frac{1}{2} i_0 \sin(2\omega t)$$

Solution:

- Original waveform: $i = i_0 \sin(\omega t)$.
- Half amplitude $\implies I_{\text{new}} = \frac{1}{2} i_0$.
- Double frequency $\implies \omega_{\text{new}} = 2\omega$.
- Substituting these parameters gives $i = \frac{1}{2} i_0 \sin(2\omega t)$.

Why other options are incorrect:

- **Opt_A:** Represents doubled amplitude ($2i_0$) with unchanged frequency.
- **Opt_B:** Contains an inverse trigonometric function, which is mathematically invalid for an AC wave.
- **Opt_D:** $i = \frac{1}{2} i_0 \sin(\omega t)$ has half amplitude but retains the original frequency ω .

Question #44 Key: (B)

KMU 2012

An alternating current of r.m.s [Formula] passes through a [Formula] resistor. What is the average power dissipated...

CORE CONCEPT AND DERIVATION

In a pure resistor, the average electrical power dissipated as heat is calculated directly from the RMS current and resistance.

Formula / Reaction:

$$P = I_{\text{rms}}^2 R$$

Solution:

- Given: $I_{\text{rms}} = 20 \text{ mA} = 20 \times 10^{-3} \text{ A} = 2 \times 10^{-2} \text{ A}$.
- Resistance: $R = 4 \text{ k}\Omega = 4000 \Omega = 4 \times 10^3 \Omega$.
- $P = (2 \times 10^{-2})^2 \times (4 \times 10^3) = (4 \times 10^{-4}) \times (4 \times 10^3) = 1.6 \text{ W}$.

Why other options are incorrect:

- Opt_A:** 0.8 W incorrectly divides the power by 2.
- Opt_C:** Result of using incorrect metric exponents (+3 instead of -3).
- Opt_D:** Metric power calculation error.

Question #45 Key: (C)

KMU 2011

The sinusoidal alternating voltage can be expressed by the equation [Formula]. The instantaneous value of alt...

CORE CONCEPT AND DERIVATION

The instantaneous value is found by substituting the time t and $\omega = \frac{2\pi}{T}$ into the given cosine waveform equation.

Formula / Reaction:

$$V(t) = V_m \cos(\omega t) = V_m \cos\left(\frac{2\pi}{T} \cdot t\right)$$

Solution:

- At $t = \frac{3T}{4}$:
- $\theta = \omega t = \left(\frac{2\pi}{T}\right) \left(\frac{3T}{4}\right) = \frac{3\pi}{2} = 270^\circ$.
- $V = V_m \cos(270^\circ) = V_m(0) = 0$.

Why other options are incorrect:

- Opt_A:** $+V_m$ occurs at $t = 0$ and $t = T$.
- Opt_B:** $-V_m$ occurs at $t = T/2$ ($\theta = \pi$).
- Opt_D:** Option C is the exact mathematical result.

Question #46 **Key: (A)**

KMU 2010

In alternating current the average value of current in a cycle is:

CORE CONCEPT AND DERIVATION

A symmetrical sinusoidal alternating current completes one full cycle consisting of equal and opposite positive and negative half-cycles.

Formula / Reaction:

$$I_{\text{avg}} = \frac{1}{T} \int_0^T I_0 \sin(\omega t) dt = 0$$

Solution:

- During the first half-cycle ($0 \rightarrow T/2$), the area under the current waveform is positive: $+I_{\text{avg(half)}} = +\frac{2I_0}{\pi}$.
- During the second half-cycle ($T/2 \rightarrow T$), the area under the current waveform is negative: $-I_{\text{avg(half)}} = -\frac{2I_0}{\pi}$.
- Summing these values over a full period gives an exact net sum of zero.

Why other options are incorrect:

- **Opt_B:** The current is continuously varying with time, not constant.
- **Opt_C:** The average over a full cycle cannot be positive because the negative half-cycle completely cancels the positive half-cycle.
- **Opt_D:** Maximum value corresponds to peak current I_0 , not the cycle average.

Question #47 **Key: (C)**

KMU 2010

The r.m.s value of alternating voltage for unit peak amplitude ([Formula]) is:

CORE CONCEPT AND DERIVATION

For a unit peak sinusoidal voltage ($V_0 = 1 \text{ V}$), the root mean square value is given by $\frac{1}{\sqrt{2}} V_0$.

Formula / Reaction:

$$V_{\text{rms}} = \frac{1}{\sqrt{2}} V_0 \approx 0.707 V_0$$

Solution:

- Evaluating the numerical fraction: $\frac{1}{\sqrt{2}} = \frac{1}{1.4142} \approx 0.707$.
- Thus, for a peak voltage of 1 V, the RMS voltage is 0.707 V.

Why other options are incorrect:

- **Opt_A:** 1.77 is an incorrect arithmetic factor.
- **Opt_B:** 17.7 represents a scaling error by a factor of 25.
- **Opt_D:** 0.0177 represents an incorrect decimal shift.

Question #48 **Key: (B)**

KMU 2010

The capacitive reactance of the AC circuit increases:

CORE CONCEPT AND DERIVATION

Capacitive reactance X_C is the opposition offered by a capacitor to the flow of alternating current and is inversely proportional to frequency.

Formula / Reaction:

$$X_C = \frac{1}{\omega C} = \frac{1}{2\pi f C}$$

Solution:

- Because $X_C \propto \frac{1}{f}$, decreasing the frequency f of the AC source causes the capacitive reactance X_C to increase.
- In the limit of direct current ($f = 0$), $X_C \rightarrow \infty$, completely blocking steady DC.

Why other options are incorrect:

- **Opt_A:** Increasing the frequency decreases X_C .
- **Opt_C:** Reactance is explicitly frequency-dependent.
- **Opt_D:** Option B is correct.

Question #49 **Key: (B)**

KMU 2009

Which of the following has least wavelength?

CORE CONCEPT AND DERIVATION

In the high-energy radiation spectrum, wavelength is inversely proportional to photon energy and frequency according to the Planck-Einstein relation $E = \frac{hc}{\lambda}$.

Formula / Reaction:

$$\lambda = \frac{c}{f}$$

Solution:

- Cosmic rays consist of ultra-high-energy astronomical particles and photons with frequencies exceeding 10^{22} Hz and wavelengths shorter than 10^{-14} m.
- X-rays have wavelengths typically ranging between 10^{-8} m and 10^{-11} m.
- Therefore, cosmic ray photons have the shortest wavelength among the choices.

Why other options are incorrect:

- **Opt_A:** α -rays are helium nuclei (matter particles), not electromagnetic waves.
- **Opt_C:** β -rays are fast electrons/positrons (matter particles), not electromagnetic waves.
- **Opt_D:** X-rays have longer wavelengths than cosmic ray photons.

Question #50 **Key: (D)**

KMU 2009

The average power loss in a capacitor in an AC circuit is:

CORE CONCEPT AND DERIVATION

Because current leads voltage by 90° in a pure capacitor, the power factor $\cos \phi = \cos(90^\circ) = 0$.

Formula / Reaction:

$$\langle P \rangle = V_{\text{rms}} I_{\text{rms}} \cos(90^\circ) = 0$$

Solution:

- The capacitor acts as an energy storage element, storing energy electrostatically and releasing it back to the circuit without net thermal dissipation.
- Thus, average power loss over a complete cycle is zero.

Why other options are incorrect:

- **Opt_A:** Apparent peak power.
- **Opt_B, Opt_C:** Time-dependent functions do not represent cycle-averaged power.

Question #51 **Key: (B)**

KMU 2007

The alternating current can be measured from its:

CORE CONCEPT AND DERIVATION

Because the cycle average of AC is zero, standard moving-coil meters based on linear magnetic deflection or chemical electrolysis average to zero. Thermal heating depends on I^2 and is unidirectional.

Formula / Reaction:

$$P_{\text{avg}} = I_{\text{rms}}^2 R$$

Solution:

- Hot-wire ammeters utilize the expansion of a metal wire heated by the current $I^2 R$.
- Because heating $H \propto I^2$, deflection is always in one direction regardless of AC alternating polarity, making it the standard method to measure RMS AC.

Why other options are incorrect:

- **Opt_A:** Standard magnetic torque reverses every half cycle; a permanent-magnet moving-coil meter oscillates rapidly around zero and reads zero.
- **Opt_C:** Chemical electrolytic effects reverse every half cycle, resulting in zero net chemical deposition.
- **Opt_D:** Only thermal effect meters can directly measure AC without rectification.

Question #52 Key: (D)

KMU 2007

Which of the following has the highest energy photon?

CORE CONCEPT AND DERIVATION

Photon energy is directly proportional to frequency and inversely proportional to wavelength across the electromagnetic spectrum.

Formula / Reaction:

$$E = hf = \frac{hc}{\lambda}$$

Solution:

- The electromagnetic spectrum in order of increasing frequency and photon energy is: Radio → Microwaves → Infrared → Visible → UV → X-rays → Gamma rays.
- Gamma rays possess the highest frequencies ($f > 10^{19}$ Hz) and therefore the most energetic photons in the electromagnetic spectrum.

Why other options are incorrect:

- Opt_A:** Visible light photons have low energies (1.8 to 3.1 eV).
- Opt_B:** X-rays have high energy (keV), but are less energetic than nuclear gamma rays.
- Opt_C:** Ultraviolet photons are lower in energy than X-rays and gamma rays.

Question #53 Key: (B)

KMU 2006

In a capacitive circuit, current and voltage phase relation is:

CORE CONCEPT AND DERIVATION

In a pure capacitor, alternating current is proportional to the rate of change of voltage across its plates: $i = C \frac{dv}{dt}$.

Formula / Reaction:

$$\text{If } v(t) = V_0 \sin(\omega t), \quad i(t) = I_0 \cos(\omega t) = I_0 \sin\left(\omega t + \frac{\pi}{2}\right)$$

Solution:

- When alternating voltage is applied to a capacitor, charge flows onto the plates immediately, so current reaches its peak before voltage builds up across the plates.
- Therefore, current leads the applied voltage by a phase angle of 90° (or $\pi/2$ radians).

Why other options are incorrect:

- Opt_A:** Current and voltage are in-phase only in a pure resistor ($\phi = 0^\circ$).
- Opt_C:** Voltage leads current by 90° in a pure inductor, not a capacitor.
- Opt_D:** A 180° phase lead represents complete phase opposition, which does not occur in a pure capacitor.

Question #54 **Key: (A)**

KMU 2006

The mean square value of the alternating current is:

CORE CONCEPT AND DERIVATION

The mean square value of a sinusoidal alternating current is the average of the squared instantaneous current over a complete cycle.

Formula / Reaction:

$$\langle i^2 \rangle = \frac{1}{T} \int_0^T I_0^2 \sin^2(\omega t) dt = \frac{I_0^2}{2}$$

Solution:

- The average value of $\sin^2(\omega t)$ over one full cycle is $\frac{1}{2}$.
- Therefore, the mean square current is $i_{\text{ms}} = \langle i^2 \rangle = \frac{i_0^2}{2}$.
- Taking the square root gives the root-mean-square value:
 $I_{\text{rms}} = \sqrt{\frac{i_0^2}{2}} = \frac{i_0}{\sqrt{2}}$.

Why other options are incorrect:

- **Opt_B:** Divides by $\sqrt{2}$, which confuses the mean square with the root mean square.
- **Opt_C:** Multiplies by 2 instead of dividing by 2.
- **Opt_D:** Multiplies by $\sqrt{2}$.