

25/06/2022

Evening



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Answers & Solutions

Time : 3 hrs.

for

M.M. : 300

JEE (Main)-2022 (Online) Phase-1

(Physics, Chemistry and Mathematics)

IMPORTANT INSTRUCTIONS:

- (1) The test is of **3 hours** duration.
- (2) The Test Booklet consists of 90 questions. The maximum marks are 300.
- (3) There are **three** parts in the question paper consisting of **Physics, Chemistry** and **Mathematics** having 30 questions in each part of equal weightage. Each part (subject) has two sections.
 - (i) **Section-A:** This section contains 20 multiple choice questions which have only one correct answer. Each question carries **4 marks** for correct answer and **-1 mark** for wrong answer.
 - (ii) **Section-B:** This section contains 10 questions. In Section-B, attempt any **five questions out of 10**. The answer to each of the questions is a numerical value. Each question carries **4 marks** for correct answer and **-1 mark** for wrong answer. For Section-B, the answer should be rounded off to the nearest integer.

PHYSICS

SECTION - A

Multiple Choice Questions: This section contains 20 multiple choice questions. Each question has 4 choices (1), (2), (3) and (4), out of which **ONLY ONE** is correct.

Choose the correct answer :

1. Given below are two statements. One is labelled as **Assertion A** and the other is labelled as **Reason R**.

Assertion A: Two identical balls *A* and *B* thrown with same velocity '*u*' at two different angles with horizontal attained the same range *R*. If *A* and *B* reached the maximum height *h*₁ and *h*₂ respectively, then $R = 4\sqrt{h_1 h_2}$.

Reason R: Product of said heights.

$$h_1 h_2 = \left(\frac{u^2 \sin^2 \theta}{2g} \right) \left(\frac{u^2 \cos^2 \theta}{2g} \right)$$

Choose the correct answer :

- (A) Both **A** and **R** are true and **R** is the correct explanation of **A**.
(B) Both **A** and **R** are true but **R** is NOT the correct explanation of **A**.
(C) **A** is true but **R** is false.
(D) **A** is false but **R** is true.

Answer (A)

Sol. $h_1 = \frac{u^2 \sin^2 \theta}{2g}$

$$h_2 = \frac{u^2 \cos^2 \theta}{2g}$$

$$\therefore \sqrt{h_1 h_2} = \frac{u^2 \sin \theta \cos \theta}{2g}$$

$$= \frac{R}{4}$$

$$\Rightarrow R = 4\sqrt{h_1 h_2}$$

2. Two buses *P* and *Q* start from a point at the same time and move in a straight line and their positions are represented by $X_P(t) = \alpha t + \beta t^2$ and $X_Q(t) = ft - t^2$. At what time, both the buses have same velocity?

(A) $\frac{\alpha - f}{1 + \beta}$

(B) $\frac{\alpha + f}{2(\beta - 1)}$

(C) $\frac{\alpha + f}{2(1 + \beta)}$

(D) $\frac{f - \alpha}{2(1 + \beta)}$

Answer (D)

Sol. $X_P = \alpha t + \beta t^2$

$$X_Q = ft - t^2$$

$$\therefore V_P = \alpha + 2\beta t$$

$$V_Q = f - 2t$$

$$\therefore V_P = V_Q$$

$$\Rightarrow \alpha + 2\beta t = f - 2t$$

$$\Rightarrow t = \frac{f - \alpha}{2(1 + \beta)}$$

3. A disc with a flat small bottom beaker placed on it at a distance *R* from its center is revolving about an axis passing through the center and perpendicular to its plane with an angular velocity ω . The coefficient of static friction between the bottom of the beaker and the surface of the disc is μ . The beaker will revolve with the disc if :

(A) $R \leq \frac{\mu g}{2\omega^2}$

(B) $R \leq \frac{\mu g}{\omega^2}$

(C) $R \geq \frac{\mu g}{2\omega^2}$

(D) $R \geq \frac{\mu g}{\omega^2}$

Answer (B)

Sol. To move together

$$\omega^2 R \leq \mu g$$

$$\Rightarrow R \leq \frac{\mu g}{\omega^2}$$

4. A solid metallic cube having total surface area 24 m² is uniformly heated. If its temperature is increased by 10°C, calculate the increase in volume of the cube.

(Given $\alpha = 5.0 \times 10^{-4} \text{ }^\circ\text{C}^{-1}$).

(A) $2.4 \times 10^6 \text{ cm}^3$

(B) $1.2 \times 10^5 \text{ cm}^3$

(C) $6.0 \times 10^4 \text{ cm}^3$

(D) $4.8 \times 10^5 \text{ cm}^3$

Answer (B)

Sol. $6 \times 10^3 = 24$

$$\Rightarrow l = 2 \text{ m}$$

$$\therefore \frac{\Delta V}{V} = 3 \times \frac{\Delta l}{l}$$

$$\begin{aligned} \Rightarrow \Delta V &= 3 \times (\alpha \Delta T) \times V \\ &= 3 \times 5 \times 10^{-4} \times 10 \times (8) \\ &= 120 \times 10^{-3} \text{ m}^3 \\ &= 120 \times 10^{-3} \times 10^6 \text{ cm}^3 \\ &= 1.2 \times 10^5 \text{ cm}^3 \end{aligned}$$

5. A copper block of mass 5.0 kg is heated to a temperature of 500°C and is placed on a large ice block. What is the maximum amount of ice that can melt?

[Specific heat of copper : $0.39 \text{ J g}^{-1} ^\circ\text{C}^{-1}$ and latent heat of fusion of water : 335 J g^{-1}]

- (A) 1.5 kg (B) 5.8 kg
(C) 2.9 kg (D) 3.8 kg

Answer (C)

Sol. $mL = \Delta Q = ms\Delta T$

$$\begin{aligned} \Rightarrow m &= \frac{5 \times 0.39 \times 10^3 \times 500}{335} \\ &= 2.9 \text{ kg} \end{aligned}$$

6. The ratio of specific heats $\left(\frac{C_p}{C_v}\right)$ in terms of degree of freedom (f) is given by:

- (A) $\left(1 + \frac{f}{3}\right)$
(B) $\left(1 + \frac{2}{f}\right)$
(C) $\left(1 + \frac{f}{2}\right)$
(D) $\left(1 + \frac{1}{f}\right)$

Answer (B)

Sol. $\frac{C_p}{C_v} = \gamma$

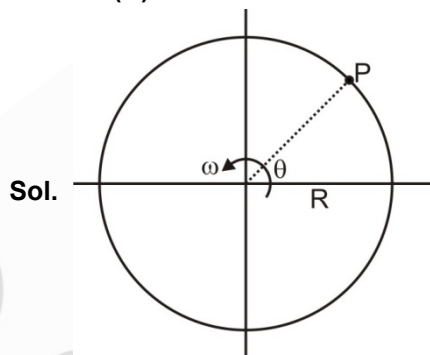
$$C_v = \left(\frac{f}{2}\right)R \text{ and } C_p - C_v = R$$

$$\Rightarrow \frac{C_p}{C_v} = \frac{1 + f/2}{f/2} = 1 + \frac{2}{f}$$

7. For a particle in uniform circular motion, the acceleration \vec{a} at any point $P(R, \theta)$ on the circular path of radius R is (when θ is measured from the positive x-axis and v is uniform speed):

- (A) $-\frac{v^2}{R} \sin \theta \hat{i} + \frac{v^2}{R} \cos \theta \hat{j}$
(B) $-\frac{v^2}{R} \cos \theta \hat{i} + \frac{v^2}{R} \sin \theta \hat{j}$
(C) $-\frac{v^2}{R} \cos \theta \hat{i} - \frac{v^2}{R} \sin \theta \hat{j}$
(D) $-\frac{v^2}{R} \hat{i} + \frac{v^2}{R} \hat{j}$

Answer (C)



Sol.

As the particle in uniform circular motion experiences only centripetal acceleration of magnitude $\omega^2 R$ or $\frac{v^2}{R}$ directed towards centre so from diagram.

$$\vec{a} = \frac{v^2}{R} \cos \theta (-\hat{i}) + \frac{v^2}{R} \sin \theta (-\hat{j})$$

8. Two metallic plates form a parallel plate capacitor. The distance between the plates is ' d '. A metal sheet of thickness $\frac{d}{2}$ and of area equal to area of each plate is introduced between the plates. What will be the ratio of the new capacitance to the original capacitance of the capacitor?
- (A) 2 : 1 (B) 1 : 2
(C) 1 : 4 (D) 4 : 1

Answer (A)

$$\text{Sol. } C_{\text{eq}} = \frac{\epsilon_0 A}{d - \frac{d}{2} + \frac{d}{2k}} = \frac{\epsilon_0 A}{\frac{d}{2}} = \frac{2\epsilon_0 A}{d}$$

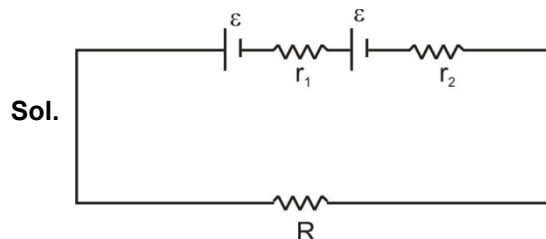
$$\text{If } C = \frac{\epsilon_0 A}{d}$$

$$\Rightarrow C_{\text{eq}} = 2C \text{ or } \frac{C_{\text{new}}}{C_{\text{old}}} = \frac{2}{1}$$

9. Two cells of same emf but different internal resistances r_1 and r_2 are connected in series with a resistance R . The value of resistance R , for which the potential difference across second cell is zero, is:

(A) $r_2 - r_1$
(B) $r_1 - r_2$
(C) r_1
(D) r_2

Answer (A)



$$I = \frac{2\varepsilon}{R + r_1 + r_2}$$

As per the question,

$$\frac{2\varepsilon}{R + r_1 + r_2} \times r_2 - \varepsilon = 0$$

$$\Rightarrow R = r_2 - r_1$$

10. Given below are two statements:

Statement-I : Susceptibilities of paramagnetic and ferromagnetic substances increase with decrease in temperature.

Statement-II : Diamagnetism is a result of orbital motions of electrons developing magnetic moments opposite to the applied magnetic field.

Choose the correct answer from the options given below:-

(A) Both Statement-I and Statement-II are true
(B) Both Statement-I and Statement-II are false
(C) Statement-I is true but Statement-II is false
(D) Statement-I is false but Statement-II is true

Answer (A)

Sol. Statement-I is true as susceptibility of ferromagnetic and paramagnetic materials is inversely related to temperature.

Statement-II is true as because of orbital motion of electrons the diamagnetic material is able to oppose external magnetic field.

11. A long solenoid carrying a current produces a magnetic field B along its axis. If the current is doubled and the number of turns per cm is halved, the new value of magnetic field will be equal to

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

Answer (A)

Sol. $B = \mu_0 ni$

Now $i \rightarrow 2i$

And $n \rightarrow \frac{n}{2}$

$$B' = \mu_0 \frac{n}{2} \times 2i = \mu_0 ni = B$$

12. A sinusoidal voltage $V(t) = 210 \sin 3000 t$ volt is applied to a series LCR circuit in which $L = 10$ mH, $C = 25 \mu\text{F}$ and $R = 100 \Omega$. The phase difference (Φ) between the applied voltage and resultant current will be:

(A) $\tan^{-1}(0.17)$ (B) $\tan^{-1}(9.46)$
(C) $\tan^{-1}(0.30)$ (D) $\tan^{-1}(13.33)$

Answer (A)

Sol. $X_L = 3000 \times 10 \times 10^{-3} = 30 \Omega$

$$X_C = \frac{1}{3000 \times 25} \times 10^6 = \frac{40}{3} \Omega$$

$$\text{So } X_L - X_C = 30 - \frac{40}{3} = \frac{50}{3} \Omega$$

$$\tan \theta = \frac{X_L - X_C}{R} = \frac{50/3}{100} = \frac{1}{6}$$

$$\text{So } \theta = \tan^{-1}(0.17)$$

13. The electromagnetic waves travel in a medium at a speed of 2.0×10^8 m/s. The relative permeability of the medium is 1.0. The relative permittivity of the medium will be:

(A) 2.25 (B) 4.25
(C) 6.25 (D) 8.25

Answer (A)

Sol. $n = \frac{c}{v} = \frac{3}{2}$

$$\sqrt{\epsilon \mu} = n$$

$$\text{So } \epsilon = \frac{9}{4} = 2.25$$

14. The interference pattern is obtained with two coherent light sources of intensity ratio 4 : 1. And the ratio $\frac{I_{\max} + I_{\min}}{I_{\max} - I_{\min}}$ is $\frac{5}{x}$. Then, the value of x will be equal to:

- (A) 3 (B) 4
(C) 2 (D) 1

Answer (B)

$$\begin{aligned} \text{Sol. } \frac{I_{\max} + I_{\min}}{I_{\max} - I_{\min}} &= \frac{I_1 + I_2 + 2\sqrt{I_1 I_2} + I_1 + I_2 - 2\sqrt{I_1 I_2}}{I_1 + I_2 + 2\sqrt{I_1 I_2} - I_1 - I_2 + 2\sqrt{I_1 I_2}} \\ &= \frac{2(I_1 + I_2)}{4\sqrt{I_1 I_2}} \\ &= \frac{\left(\frac{I_1}{I_2} + 1\right)}{2\sqrt{\frac{I_1}{I_2}}} = \frac{4+1}{2 \times 2} = \frac{5}{4} \end{aligned}$$

So $x = 4$

15. A light whose electric field vectors are completely removed by using a good polaroid, allowed to incident on the surface of the prism at Brewster's angle. Choose the most suitable option for the phenomenon related to the prism.
- (A) Reflected and refracted rays will be perpendicular to each other.
(B) Wave will propagate along the surface of prism.
(C) No refraction, and there will be total reflection of light.
(D) No reflection, and there will be total transmission of light.

Answer (D)

Sol. When electric field vector is completely removed and incident on Brewster's angle then only refraction takes place.

16. A proton, a neutron, an electron and an α -particle have same energy. If λ_p , λ_n , λ_e and λ_α are the de Broglie's wavelengths of proton, neutron, electron and α particle respectively, then choose the correct relation from the following:
- (A) $\lambda_p = \lambda_n > \lambda_e > \lambda_\alpha$
(B) $\lambda_\alpha < \lambda_n < \lambda_p < \lambda_e$
(C) $\lambda_e < \lambda_p = \lambda_n > \lambda_\alpha$
(D) $\lambda_e = \lambda_p = \lambda_n = \lambda_\alpha$

Answer (B)

Sol. de Broglie wavelength $\lambda = \frac{h}{p}$

$$\Rightarrow \lambda = \frac{h}{\sqrt{2mK}}$$

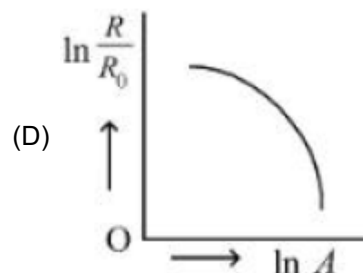
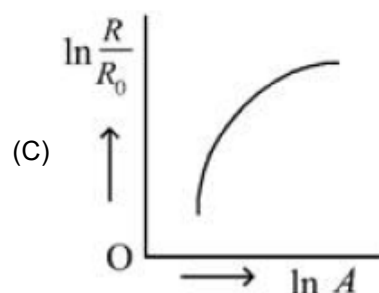
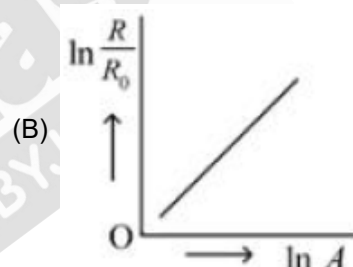
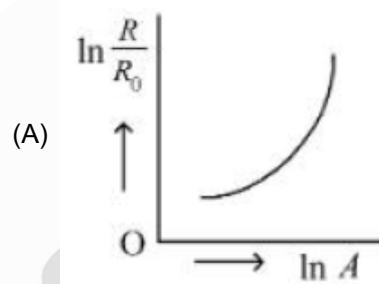
Where K : kinetic energy

$$\Rightarrow \text{For some } K, \lambda \propto \frac{1}{\sqrt{m}}$$

Since $m_\alpha > m_n > m_p > m_e$

$$\Rightarrow \lambda_\alpha < \lambda_n < \lambda_p < \lambda_e$$

17. Which of the following figure represents the variation of $\ln\left(\frac{R}{R_0}\right)$ with $\ln A$ (if R = radius of a nucleus and A = its mass number)



Answer (B)

Sol. We know that

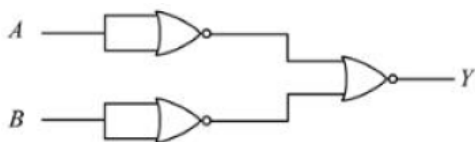
$$R = R_0 A^{1/3}$$

$$\Rightarrow \ln \left(\frac{R}{R_0} \right) = \frac{1}{3} \ln(A)$$

$\underbrace{\hspace{1cm}}_y = \underbrace{\frac{1}{3}}_m \underbrace{\ln(A)}_x$

\Rightarrow Straight line

18. Identify the logic operation performed by the given circuit:



- (A) AND gate
(B) OR gate
(C) NOR gate
(D) NAND gate

Answer (A)

Sol. According to the circuit,

$$Y = (A' + B')$$

$$\Rightarrow Y = AB$$

\Rightarrow AND gate

19. Match List I with List II

	List I		List II
A.	Facsimile	I.	Static Document Image
B.	Guided media Channel	II.	Local Broadcast Radio
C.	Frequency Modulation	III.	Rectangular wave
D.	Digital Single	IV.	Optical Fiber

Choose the correct answer from the following options:

- (A) A-IV, B-III, C-II, D-I
(B) A-I, B-IV, C-II, D-III
(C) A-IV, B-II, C-III, D-I
(D) A-I, B-II, C-III, D-IV

Answer (B)

Sol. The correct match is:

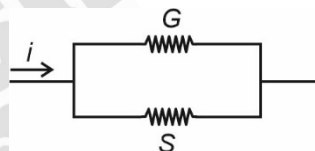
Facsimile	–	Static Document Image
Guided Media Channel	–	Optical Fiber
Frequency Modulation	–	Local Broadcast Radio
Digital single	–	Rectangular Wave

20. If n represents the actual number of deflections in a converted galvanometer of resistance G and shunt resistance S . Then the total current I when its figure of merit is K will be

- (A) $\frac{KS}{(S+G)}$ (B) $\frac{(G+S)}{nKS}$
(C) $\frac{nKS}{(G+S)}$ (D) $\frac{nK(G+S)}{S}$

Answer (D)

Sol. According to the information, current through galvanometer = nK



$$\Rightarrow \frac{S}{S+G} i = nK$$

$$\Rightarrow i = \frac{nK(S+G)}{S}$$

SECTION - B

Numerical Value Type Questions: This section contains 10 questions. In Section B, attempt any five questions out of 10. The answer to each question is a **NUMERICAL VALUE**. For each question, enter the correct numerical value (in decimal notation, truncated/rounded-off to the second decimal place; e.g. 06.25, 07.00, –00.33, –00.30, 30.27, –27.30) using the mouse and the on-screen virtual numeric keypad in the place designated to enter the answer.

1. For $z = a^2 x^3 y^{\frac{1}{2}}$, where 'a' is a constant. If percentage error in measurement of 'x' and 'y' are 4% and 12%, respectively, then the percentage error for 'z' will be _____ %.

Answer (18)

Sol. % error in $z = 3 \times 4 + \frac{1}{2} \times 12$

$$= 12 + 6 = 18\%$$

2. A curved in a level road has a radius 75 m. The maximum speed of a car turning this curved road can be 30 m/s without skidding. If radius of curved road is changed to 48 m and the coefficient of friction between the tyres and the road remains same, then maximum allowed speed would be _____ m/s.

Answer (24)

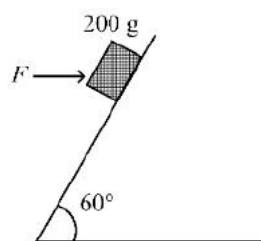
Sol. $\therefore v = \sqrt{\mu g r}$

$$\Rightarrow \frac{v_1}{v_2} = \sqrt{\frac{r_1}{r_2}}$$

$$\Rightarrow \frac{30}{v_2} = \sqrt{\frac{75}{48}} = \sqrt{\frac{25}{16}} = \frac{5}{4}$$

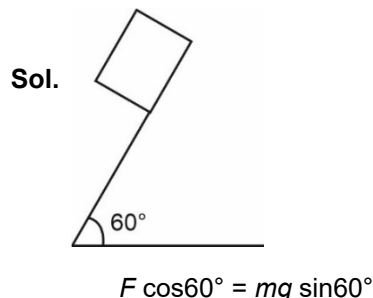
$$\Rightarrow v_2 = 24 \text{ m/s}$$

3. A block of mass 200 g is kept stationary on a smooth inclined plane by applying a minimum horizontal force $F = \sqrt{x}$ N as shown in figure.



The value of $x =$ _____.

Answer (12)



$$F \times \frac{1}{2} = 0.2 \times 10 \times \frac{\sqrt{3}}{2}$$

$$\Rightarrow F = 2\sqrt{3}$$

$$\Rightarrow F = \sqrt{12} \text{ N}$$

$$\therefore x = 12$$

4. Moment of Inertia (M.I.) of four bodies having same mass ' M ' and radius ' $2R$ ' are as follows :

I_1 = M.I. of solid sphere about its diameter

I_2 = M.I. of solid cylinder about its axis

I_3 = M.I. of solid circular disc about its diameter.

I_4 = M.I. of thin circular ring about its diameter

If $2(I_2 + I_3) + I_4 = x \cdot I_1$ then the value of x will be _____.

Answer (5)

Sol. $2\left(\frac{1}{2} + \frac{1}{4}\right) \times M(2R)^2 + \frac{1}{2}M(2R)^2 = x \frac{2}{5}M(2R)^2$

$$\Rightarrow 1 + \frac{1}{2} + \frac{1}{2} = x \times \frac{2}{5}$$

$$\Rightarrow x = 5$$

5. Two satellites S_1 and S_2 are revolving in circular orbits around a planet with radius $R_1 = 3200$ km and $R_2 = 800$ km respectively. The ratio of speed of satellite S_1 to the speed of satellite S_2 in their respective orbits would be $\frac{1}{x}$ where $x =$

Answer (2)

Sol. $v = \sqrt{\frac{GM}{R}}$

$$\Rightarrow \frac{v_1}{v_2} = \sqrt{\frac{R_2}{R_1}}$$

$$\frac{v_2}{v_1} = \sqrt{\frac{3200}{800}} = 2$$

$$\Rightarrow \frac{v_1}{v_2} = \frac{1}{2}$$

$$x = 2$$

6. When a gas filled in a closed vessel is heated by raising the temperature by 1°C , its pressure increases by 0.4%. The initial temperature of the gas is ____ K.

Answer (250)

Sol. $PV = nRT$

$$\text{So, } \frac{dP}{P} \times 100 = \frac{dT}{T} \times 100$$

$$0.4 = \frac{1}{T} \times 100$$

$$\Rightarrow T = 250 \text{ K}$$

7. 27 identical drops are charged at 22 V each. They combine to form a bigger drop. The potential of the bigger drop will be ____ V.

Answer (198)

Sol. Let the charge on one drop is q and its radius is r .

$$\text{So for one drop } V = \frac{kq}{r}$$

$$\text{For 27 drops merged new charge will be } Q = 27q$$

$$\text{and new radius is } R = 3r$$

So new potential is

$$V' = \frac{kQ}{R} = 9 \frac{kq}{r} = 9 \times 22 \text{ V}$$

$$= 198 \text{ V}$$

8. The length of a given cylindrical wire is increased to double of its original length. The percentage increase in the resistance of the wire will be ____ %.

Answer (300)

Sol. Volume is constant so on length doubled

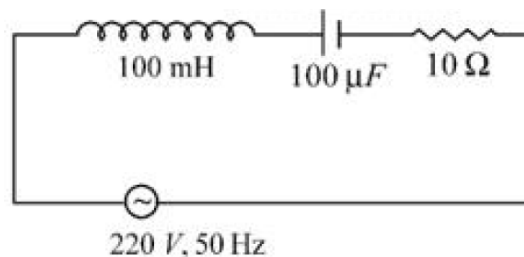
Area is halved so

$$R = \rho \frac{l}{A} \text{ and } R' = \rho \frac{2l}{\frac{A}{2}} = 4\rho \frac{l}{A} = 4R$$

So percentage increase will be

$$R\% = \frac{4R - R}{R} \times 100 = 300\%$$

9. In a series LCR circuit, the inductance, capacitance and resistance are $L = 100 \text{ mH}$, $C = 100 \mu\text{F}$ and $R = 10 \Omega$ respectively. They are connected to an AC source of voltage 220 V and frequency of 50 Hz. The approximate value of current in the circuit will be ____ A.



Answer (22)

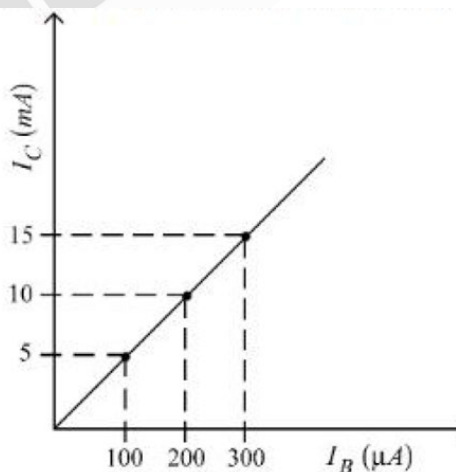
$$\text{Sol. } Z = \sqrt{R^2 + (X_L - X_C)^2}$$

$$= \sqrt{10^2 + \left[10\pi - \frac{100}{\pi}\right]^2} \Omega$$

$$\approx 10 \Omega$$

$$\Rightarrow \text{Current} = \frac{220}{10} \text{ A} = 22 \text{ A}$$

10. In an experiment of CE configuration of n - p - n transistor, the transfer characteristics are observed as given in figure.



If the input resistance is 200Ω and output resistance is 60Ω , the voltage gain in this experiment will be ____.

Answer (15)

$$\text{Sol. Voltage gain} = \frac{I_C R_o}{I_B R_i}$$

$$= \frac{(10 \text{ mA})(60 \Omega)}{(200 \mu\text{A})(200 \Omega)}$$

$$\Rightarrow \text{Voltage gain} = 15$$