JEE–MAIN EXAMINATION – JUNE, 2022

25 June S - 02 Paper Solution

SECTION-A

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.

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

Choose the CORRECT answer :

(A) Both A and R are true and R is the correct explanation of A.

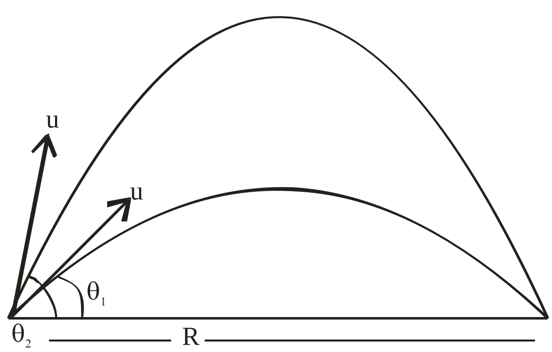
(B) Both A and R are true but R is NOT the correct explanation of A.

(C) A is true but R is false

(D) A is false but R is true

Ans. (A)

Sol. For same range $\theta_1 + \theta_2 = 90^0$



$$h_1 = \frac{u^2 \sin^2\theta_1}{2g} \qquad h_2 = \frac{u^2 \sin^2\theta_2}{2g}$$

$$h_1 h_2 = \frac{u^2 \sin^2\theta_1}{2g} \times \frac{u^2 \sin^2\theta_2}{2g}$$

$$\theta_2 = 90 - \theta_1$$

$$h_1 h_2 = \frac{u^2 \sin^2\theta_1}{2g} \cdot \frac{u^2 \cos^2\theta_1}{2g}$$

$$= \left[\frac{u^2 \sin\theta_1 \cos\theta_1}{2g}\right]^2$$

$$= \left[\frac{u^2 \sin\theta_1 \cos\theta_1}{2g} \times \frac{2}{2}\right]^2 = \frac{R^2}{16}$$

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

So R is correct explanation of A

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

Ans. (D)

Sol. $X_P(t) = \alpha t + \beta t^2 \qquad X_Q = ft - t^2$

$V_P(t) = \alpha + 2\beta t \qquad V_Q = f - 2t$

$V_P = V_Q$

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

$$t = \frac{f - \alpha}{2\beta + 2}$$

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 :

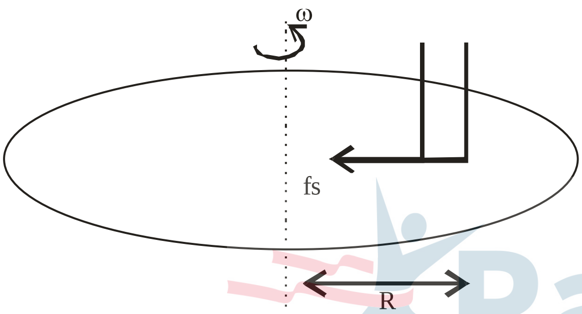
(A) $R \le \frac{\mu g}{2\omega^2}$ (B) $R \le \frac{\mu g}{\omega^2}$

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

O

Ans. (B)

Sol. For beaker to move with disc



$f_s = m\omega^2 R$

We know that $f_s \le f_{s\,max}$

$m\omega^2 R \le \mu m g$

$R \le \frac{\mu g}{\omega^2}$

4. A solid metallic cube having total surface area 24 m^2 is uniformly heated. If its temperature is increased by 10°C, calculate the increase in volume of the cube $\left(\text{Given} : \alpha = 5.0 \times 10^{-4}\,°C^{-1}\right)$

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

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

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

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

Ans. (B)

Sol. Increase in volume $\Delta V = \gamma V_0 \Delta T$

$\gamma = 3\alpha$

So $\Delta V = (3\alpha) V_0 \Delta T$

Total surface area = $6a^2$, where a is side length

$24 = 6a^2$ a= 2m

Volume $V_0 = (2)^3 = 8m^3$

$\Delta V = (3 \times 5 \times 10^{-4})(8) \times 10$

$= 1.2 \times 10^5 cm^3$

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: $0.39\,J\,g^{-1}\,°C^{-1}$ 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

Ans. (C)

Sol. Heat given by block to get 0ºC temperature

$\Delta Q_1 = 5 \times (0.39 \times 10^3) \times (500 - 0)$

$= 975 \times 10^3 J$

Heat absorbed by ice to melt m mass

$\Delta Q_2 = m \times (335 \times 10^3) J$

$\Delta Q_1 = \Delta Q_2$

$m \times (335 \times 10^3) = 975 \times 10^3$

$m = \frac{975}{335} = 2.910\,kg$

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) $\left(1 + \frac{1}{f}\right)$

Ans. (B)

Sol. Molar heat capacity at constant volume $C_V = \frac{fR}{2}$

where f is degree of freedom.

Molar heat capacity at constant pressure can be written as $C_P = R + C_V = R + \frac{fR}{2} = \left(1 + \frac{f}{2}\right)R$

So $\frac{C_P}{C_v} = 1 + \frac{2}{f}$

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

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

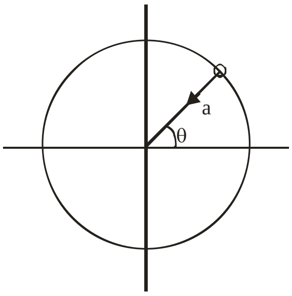
(B) $-\frac{v^2}{R}\cos\theta\hat{i} + \frac{v^2}{R}\sin\theta\hat{j}$

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

(D) $-\frac{v^2}{R}\hat{i} + \frac{v^2}{R}\hat{j}$

Ans. (C)

Sol. $a = |\vec{a}| = \frac{V^2}{R}$



$\vec{a} = -a\cos\theta\hat{i} - a\sin\theta\hat{j}$

$= -\frac{V^2}{R}\cos\theta\hat{i} - \frac{V^2}{R}\sin\theta\hat{j}$

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

Ans. (A)

Sol. $C_1 = \frac{\epsilon_0 A}{d}$

$C_2 = \frac{\epsilon_0 A}{\frac{d}{2} + \frac{d/2}{\infty}} = \frac{2\epsilon_0 A}{d}$

$\frac{C_2}{C_1} = \frac{2}{1}$

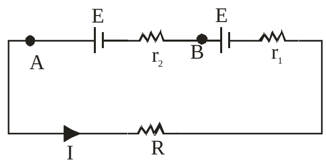
9. Two cells of same emf but different internal resistances r_1 and r_2 are connected in series with a resistance R. The value of resistance R, for which the potential difference across second cell is zero, is

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

(C) r_1 (D) r_2

Ans. (A)

Sol. $I = \frac{2E}{R + r_1 + r_2}$ **.....(i)**



But $V_A - V_B = E - Ir_2 = 0$

$\Rightarrow I = \frac{E}{r_2}$ ....(ii)

Comparing values of I from (i) and (ii)

$\frac{E}{r_2} = \frac{2E}{R + r_1 + r_2}$

$\Rightarrow R = r_2 - r_1$

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.

Ans. (A)

Sol. According to curie's law, magnetic susceptibility is

inversely proportional to temperature for a fixed value of external magnetic field i.e. $\chi = \frac{C}{T}$.

The same is applicable for ferromagnet & the relation is given as $\chi = \frac{C}{T - T_C}$ (T_C is curie temperature)

Diamagnetism is due to non-cooperative behaviour of orbiting electrons when exposed to external magnetic field.

Hence option (A).

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) 2 B

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

Ans. (A)

Sol. $B_1 = \mu_0 nI$

$B_2 = \mu_0 \left(\frac{n}{2}\right)(2I)$

$\Rightarrow B_1 = B_2$

12. A sinusoidal voltage V(t) = 210 sin 3000t volt is applied to a series LCR circuit in which L = 10 mH, C = 25 μF and R = 100Ω. 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) $\tan^{-1}(13.33)$

Ans. (A)

Sol. $X_L = 10^{-2} \times 3000 = 30\Omega$

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

$X = X_L - X_C$

$= 30 - \frac{40}{3} = \frac{50}{3}$

$\tan\delta = \frac{X}{R} = \frac{50}{3 \times 100} = \frac{1}{6}$

$\delta = \tan^{-1}\left(\frac{1}{6}\right) = \tan^{-1}(0.17)$

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

Ans. (A)

Sol. $V = 2 \times 10^8 m/s$

$C = 3 \times 10^8 m/s$

$\frac{C}{V} = \sqrt{\mu_r \epsilon_r}$

$\frac{9}{4} = 1 \times \epsilon_r$

$\epsilon_r = \frac{9}{4} = 2.25$

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

Ans. (D)

Sol. $\frac{I_1}{I_2}=4$

$$\frac{I_{max}}{I_{min}}=\left[\frac{\sqrt{I_1}+\sqrt{I_2}}{\sqrt{I_1}-\sqrt{I_2}}\right]^2$$

$$\frac{I_{max}}{I_{min}}=\left[\frac{2\sqrt{I_2}+\sqrt{I_2}}{2\sqrt{I_2}-\sqrt{I_2}}\right]^2$$

$$\frac{I_{max}}{I_{min}}=9$$

$$\frac{I_{max}+I_{min}}{I_{max}-I_{min}}=\frac{10}{8}$$

$$\frac{5}{x}=\frac{10}{8}$$

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

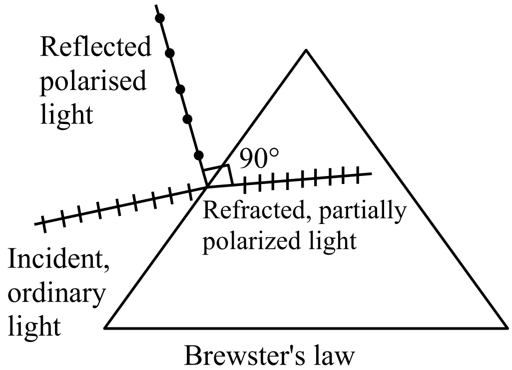
(B) Wave will propagate along the surface of prism

(C) No refraction, and there will be total reflection of light.

(D) No reflection and there will be total transmission of light.

Ans. (D)

Sol.



Brewster's law

But as the incident light electric field vectors are completely removed so there will be no reflection and there will be total transmission of light, explained by an experiment in NCERT.

[Reference NCERT Part-2 Pg-380, (A special case of total transmission)]

Note : Since direction of polarization is not mentioned hence most suitable option (D) corresponding to case in which electric field is absent perpendicular to plane consisting incident and normal.

16. A proton, a neutron, an electron and an α-particle have same energy. If $\lambda_p, \lambda_n, \lambda_e$ 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) $\lambda_e=\lambda_p=\lambda_n=\lambda_\alpha$

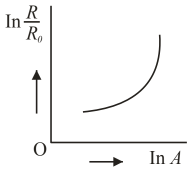
Ans. (B)

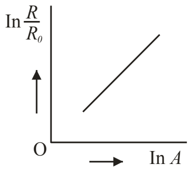
Sol. $\lambda=\frac{h}{\sqrt{2Em}}$

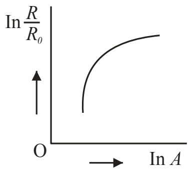
$$\lambda\propto\frac{1}{\sqrt{m}}$$

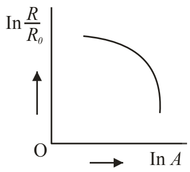
$\therefore$ $\lambda_e>\lambda_p>\lambda_n>\lambda_\alpha$

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)

(A) 

(B) 

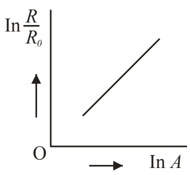
(C) 

(D) 

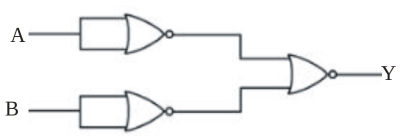
Ans. (B)

Sol. $R = R_0 A^{\frac{1}{3}}$

$$\ln\frac{R}{R_0} = \frac{1}{3}\ln A$$



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



(A) AND gate (B) OR gate

(C) NOR gate (D) NAND gate

Ans. (A)

Sol. $=\overline{\left[\overline{\overline{A+A}}+\overline{\overline{B+B}}\right]}$

$Y = \overline{\overline{A}+\overline{B}}$ (D' MORGAN LAW)

Y = AB

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 Signal	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

Ans. (B)

Sol. Question based on the theory given in NCERT.

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) $\frac{nK(G+S)}{S}$

Ans. (D)

Sol.

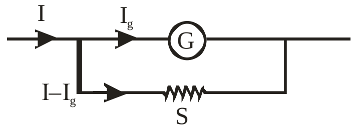


Figure of merit $\frac{I_g}{\theta} = K$

$I_g = Kn$

$I = \frac{I_g}{s}(G+S)$

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

SECTION-B

1. For $z = a^2x^3y^{\frac{1}{2}}$, 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 %.

Ans. (18)

Sol. $z = a^2x^3y^{1/2}$

$\frac{\Delta z}{z} = \frac{2\Delta a}{a} + \frac{3\Delta x}{x} + \frac{1}{2}\frac{\Delta y}{y}$

a is constant

$\frac{\Delta z}{z} \times 100 = 3(4\%) + \frac{1}{2}(12\%) = 18\%$

2. A curved in a level road has a radius 75m. 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.

Ans. (24)

Sol. $f_{s\max} = \frac{mv^2}{R}$

$\mu mg = \frac{mv^2}{R}$

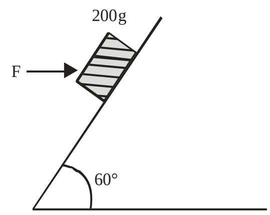
$v = \sqrt{\mu Rg}$

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

$\frac{v_2}{30} = \sqrt{\frac{48}{75}}$

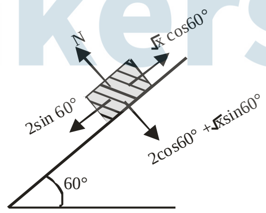
$v_2 = 24 m/s$

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 = ________.



Ans. (12) Sol.

mg = 2N



$\sqrt{x}\frac{1}{2} = \frac{2\sqrt{3}}{2}$

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

Ans. (5)

Sol. $I_1 = \frac{2}{5}M(2R)^2 = \frac{8}{5}MR^2$

$I_1 = \frac{1}{2}M(2R)^2 = 2MR^2$

$I_3 = \frac{M(2R)^2}{4} = MR^2$

$I_4 = \frac{M(2R)^2}{2} = 2MR^2$

$2(I_2 + I_3) + I_4 = x\, I_1$

$8MR^2 = x\frac{8}{5}MR^2$

$x = 5$

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 =

Ans. (2)

Sol. $V = \frac{GM}{r} \Rightarrow \frac{V_1}{V_2} = \sqrt{\frac{800}{3200}} = \frac{1}{2}$

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

Ans. (250)

Sol. $pV = nRT$

$\Delta P.V = nR\Delta T$

$\Rightarrow \quad \frac{\Delta P}{P} = \frac{\Delta T}{T} = \frac{0.4}{100}$

$\Rightarrow \quad T = \frac{100 \times 1}{0.4} = 250K$

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

Ans. (198)

Sol. $q \rightarrow nq$

$n\frac{4}{3}\pi r^3 = \frac{4}{3}\pi(r')^3$

$\Rightarrow \; r' = n^{\frac{1}{3}}r$

$V = \frac{kq}{r} \propto \frac{n}{n^{1/3}} \propto n^{2/3} \propto 27^{2/3} \Rightarrow v' = 9V = 9 \times 22 = 198$

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 ____%.

Ans. (300)

Sol. $V' = V$

$\ell'A = \ell A$

$2\ell A' = \ell A$

$A' = \frac{A}{2}$

$R = \rho\frac{\ell}{A}$ ... (i)

$\ell' = 2\ell$

$A' = \frac{A}{2}$

$R' = \frac{\rho\ell'}{A'} = \frac{\rho 2\ell}{\frac{A}{2}}$

$R' = \frac{4\rho\ell}{A}$

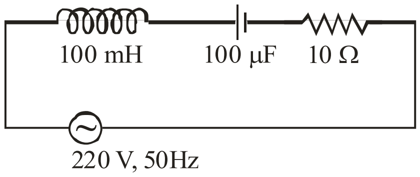
R' = 4R from equation (i)

% increase in resistance

$= \frac{R' - R}{R} \times 100 = \frac{4R - R}{R} \times 100$

= 300 %

9. In a series LCR circuit, the inductance, capacitance and resistance are L = 100mH, C = 100μF and R = 10Ω respectively. They are connected to an AC source of voltage 220V and frequency of 50 Hz. The approximate value of current in the circuit will be____ A.



Ans. (22)

Sol. $X_L = \omega L = 2\pi \times 50 \times 10^{-1} = 10\pi$

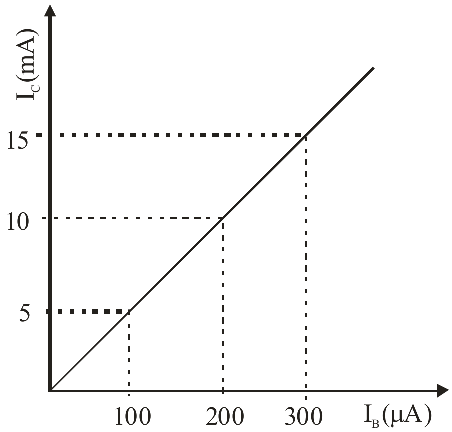
$X_X = \frac{1}{\omega C} = \frac{1}{2\pi \times 50} \times 10^4 = \frac{100}{\pi}$

$R = 10\Omega$

$Z = \sqrt{\left(10\pi - \frac{100}{\pi}\right)^2 + 10^2} \simeq 10\Omega$

$i = \frac{E}{2} \simeq \frac{220}{10} \simeq 22\text{Amp}$

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 _____

Ans. (15)

Sol. Voltage Gain $= \frac{I_C}{I_B} \times \frac{R_0}{R_I} = \frac{10 \times 10^{-3}}{200 \times 10^{-6}} \times \frac{60}{200} = 15$