

FINAL JEE-MAIN EXAMINATION – JUNE, 2022

 (Held On Saturday 25th June, 2022)

TIME : 3:00 PM to 6:00 PM

PHYSICS
TEST PAPER WITH 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.

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

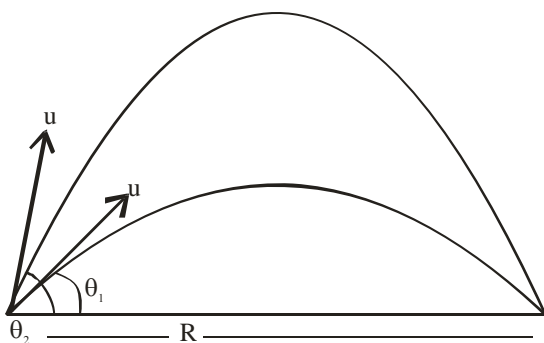
Choose the CORRECT answer :

- (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

Official Ans. by NTA (A)

Allen Ans. (A)

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



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

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

$$\theta_2 = 90 - \theta_1$$

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

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

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

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

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

Official Ans. by NTA (D)

Allen Ans. (D)

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

$$V_P(t) = \alpha + 2\beta t$$

$$V_Q = f - 2t$$

$$V_P = V_Q$$

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

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

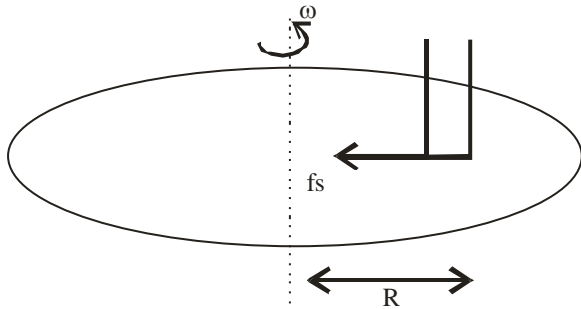
3. A disc with a flat small bottom beaker placed on it at a distance R from its center is revolving about an axis passing through the center and perpendicular to its plane with an angular velocity ω . The coefficient of static friction between the bottom of the beaker and the surface of the disc is μ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

(A) $R \leq \frac{\mu g}{2\omega^2}$ (B) $R \leq \frac{\mu g}{\omega^2}$
 (C) $R \geq \frac{\mu g}{2\omega^2}$ (D) $R \geq \frac{\mu g}{\omega^2}$

Official Ans. by NTA (B)

Allen Ans. (B)

Sol. For beaker to move with disc



$$f_s = m\omega^2 R$$

We know that $f_s \leq f_{s\max}$

$$m\omega^2 R \leq \mu mg$$

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

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

Official Ans. by NTA (B)

Allen Ans. (B)

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

$$\gamma = 3\alpha$$

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

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

$$24 = 6a^2 \quad a = 2\text{m}$$

$$\text{Volume } V_0 = (2)^3 = 8\text{m}^3$$

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

$$= 1.2 \times 10^5 \text{ cm}^3$$

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: $0.39 \text{ J g}^{-1} \text{ }^\circ\text{C}^{-1}$ 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

Official Ans. by NTA (C)

Allen Ans. (C)

Sol. Heat given by block to get 0°C temperature

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

$$= 975 \times 10^3 \text{ J}$$

Heat absorbed by ice to melt m mass

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

$$\Delta Q_1 = \Delta Q_2$$

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

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

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

Official Ans. by NTA (B)

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

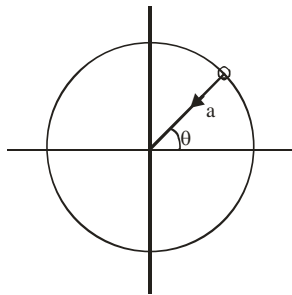
7. For a particle in uniform circular motion, the acceleration \vec{a} at any point $P(R, \theta)$ on the circular path of radius R is (when θ is measured from the positive x -axis and v is uniform speed) :

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

Official Ans. by NTA (C)

Allen 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

Official Ans. by NTA (A)

Allen Ans. (A)

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

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

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

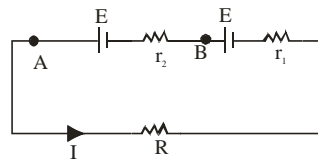
9. Two cells of same emf but different internal resistances r_1 and r_2 are connected in series with a resistance R . The value of resistance R , for which the potential difference across second cell is zero, is

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

Official Ans. by NTA (A)

Allen Ans. (A)

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



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

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

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.

Official Ans. by NTA (A)

Allen 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) $\frac{B}{2}$

Official Ans. by NTA (A)

Allen Ans. (A)

Sol. $B_1 = \mu_0 n I$

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

$$\Rightarrow B_1 = B_2$$

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

Official Ans. by NTA (A)

Allen 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

Official Ans. by NTA (A)

Allen 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

Official Ans. by NTA (B)

Allen Ans. (D)

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

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

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

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

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

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

$$x = 4$$

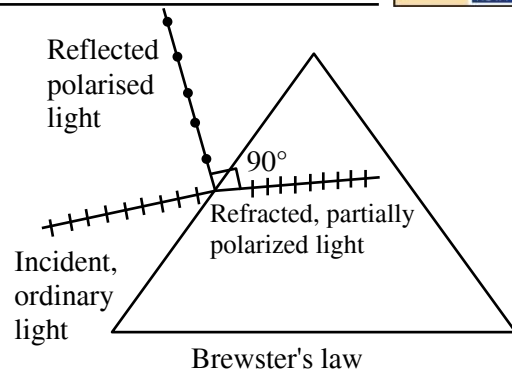
15. A light whose electric field vectors are completely removed by using a good Polaroid, allowed to incident on the surface of the prism at Brewster's angle. Choose the most suitable option for the phenomenon related to the prism.

- (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.

Official Ans. by NTA (D)

Allen Ans. (D)

Sol.



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) $\lambda_e = \lambda_p = \lambda_n = \lambda_\alpha$

Official Ans. by NTA (B)

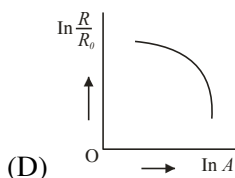
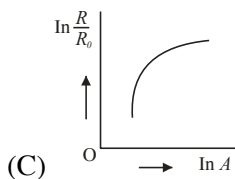
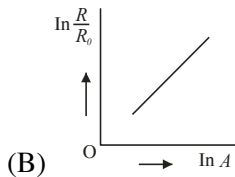
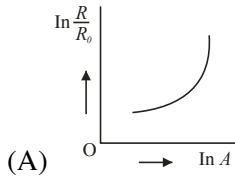
Allen Ans. (B)

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

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

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

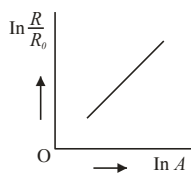
17. Which of the following figure represents the variation of $\ln\left(\frac{R}{R_0}\right)$ with $\ln A$ (If R = radius of a nucleus and A = its mass number)



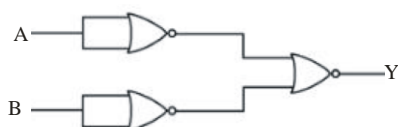
Official Ans. by NTA (B)

Allen 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

Official Ans. by NTA (A)

Allen Ans. (A)

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

$Y = \overline{\overline{A + B}}$ (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

Official Ans. by NTA (B)

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

Official Ans. by NTA (D)

Allen Ans. (D)

Sol.

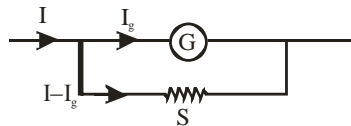


Figure of merit $\frac{I_g}{\theta} = K$

$I_g = Kn$

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

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

SECTION-B

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

Official Ans. by NTA (18)

Allen 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.

Official Ans. by NTA (24)

Allen Ans. (24)

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

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

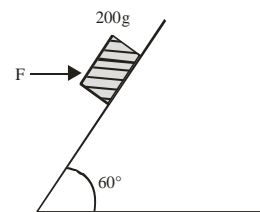
$v = \sqrt{\mu Rg}$

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

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

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

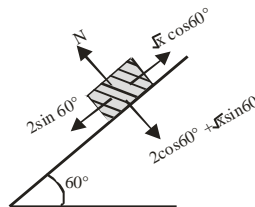
3. A block of mass 200 g is kept stationary on a smooth inclined plane by applying a minimum horizontal force $F = \sqrt{x} \text{ N}$ as shown in figure. The value of x = _____.



Official Ans. by NTA (12)

Allen Ans. (12)

Sol. $mg = 2 \text{ N}$



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

$x = 12$

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

Official Ans. by NTA (5)

Allen 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 $x =$

Official Ans. by NTA (2)

Allen 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.

Official Ans. by NTA (250)

Allen Ans. (250)

Sol. $pV = nRT$

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

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

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

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.

Official Ans. by NTA (198)

Allen Ans. (198)

Sol. $q \rightarrow nq$

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

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

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

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 _____ %.

Official Ans. by NTA (300)

Allen Ans. (300)

Sol. $V' = V$

$$\ell' A = \ell A$$

$$2\ell A' = \ell A$$

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

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

$$\ell' = 2\ell$$

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

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

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

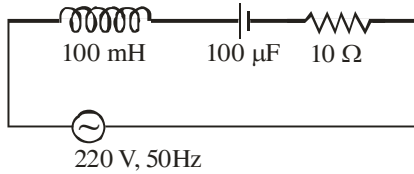
$$R' = 4R \text{ from equation (i)}$$

% 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 $L = 100\text{mH}$, $C = 100\mu\text{F}$ and $R = 10\Omega$ 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.



Official Ans. by NTA (22)

Allen Ans. (22)

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

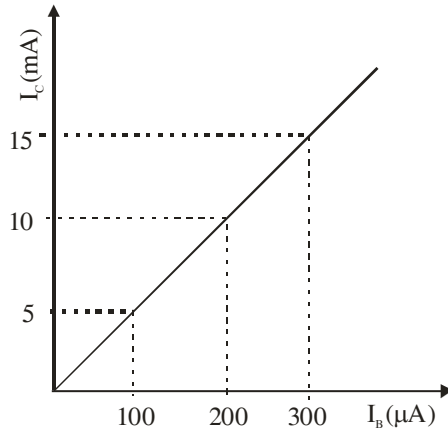
$$X_C = \frac{1}{\omega C} = \frac{1}{2\pi \times 50} \times 10^4 = \frac{100}{\pi}$$

$$R = 10\Omega$$

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

$$i = \frac{E}{Z} \approx \frac{220}{10} \approx 22\text{Amp}$$

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 ____

Official Ans. by NTA (15)

Allen Ans. (15)

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