FINAL JEE–MAIN EXAMINATION – JUNE, 2022

(Held On Wednesday 29th June, 2022) **TIME : 9 : 00 AM to 12 : 00 PM**

PHYSICS | TEST PAPER WITH SOLUTION

SECTION-A

1. Two balls A and B are placed at the top of 180 m tall tower. Ball A is released from the top at t = 0 s. Ball B is thrown vertically down with an initial velocity 'u' at t = 2 s. After a certain time, both balls meet 100 m above the ground. Find the value of 'u' in ms^{-1}. [use g = 10 ms^{-2}] :

(A) 10 (B) 15

(C) 20 (D) 30

Official Ans. by NTA (D)

Ans. (D)

Sol. Let they meet at time t.

$$t = \sqrt{\frac{2h}{g}} = \sqrt{\frac{2 \times 80}{10}}$$

= 4 sec

Time taken by ball B to meet A = 2 sec

using $S = ut + \frac{1}{2}at^2$

$$-80 = -u \times 2 + \frac{1}{2}(-10)(2)^2$$

u = 30

2. A body of mass M at rest explodes into three pieces, in the ratio of masses 1 : 1 : 2. Two smaller pieces fly off perpendicular to each other with velocities of 30 ms^{-1} and 40 ms^{-1} respectively. The velocity of the third piece will be :

(A) 15 ms^{-1} (B) 25 ms^{-1}

(C) 35 ms^{-1} (D) 50 ms^{-1}

Official Ans. by NTA (B)

Ans. (B)

Sol. Mass of pieces by $\frac{M}{4}, \frac{M}{4}, \frac{M}{2}$

conserving momentum

$$\vec{P}_1 + \vec{P}_2 + \vec{P}_3 = 0$$

$$\vec{P}_3 = -(\vec{P}_1 + \vec{P}_2)$$

As $\vec{P}_1$ & $\vec{P}_2$ are perpendicular

so $P_3 = \sqrt{P_1^2 + P_2^2}$

$$_3 = (50)\frac{M}{4}$$

& $P_3 = \frac{M}{2}v$

3. The activity of a radioactive material is 2.56 × 10^{-3} Ci. If the half life of the material is 5 days, after how many days the activity will become 2 × 10^{-5} Ci?

(A) 30 days (B) 35 days

(C) 40 days (D) 25 days

Official Ans. by NTA (B)

Ans. (B)

Sol. $\frac{A}{A_0} = \frac{N}{N_0}$

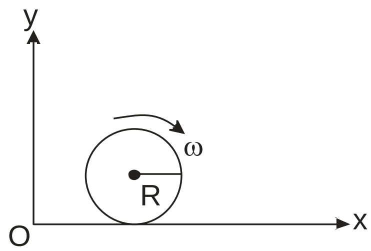
$$\frac{2 \times 10^{-5}}{2.56 \times 10^{-3}} = \frac{N}{N_0}$$

$$\frac{N}{N_0} = \frac{1}{128} \Rightarrow N = \frac{N_0}{128}$$

After 7 half life activity comes down to given value T = 7 × 5

= 35 days

4. A spherical shell of 1 kg mass and radius R is rolling with angular speed ω on horizontal plane (as shown in figure). The magnitude of angular momentum of the shell about the origin O is $\frac{a}{3}R^2\omega$. The value of a will be :



(A) 2 (B) 3

(C) 5 (D) 4

Official Ans. by NTA (C)

Ans. (C)

Sol. L_0 = angular momentum of shell about O.

As shell is rolling

so $V_{cm} = \omega R$

$L_0 = mV_{cm}R + I\omega$

$$= 1 \times \omega R \times R + \frac{2}{3}R^2\omega$$

$$= \frac{5}{3}R^2\omega$$

5. A cylinder of fixed capacity of 44.8 litres contains helium gas at standard temperature and pressure. The amount of heat needed to raise the temperature of gas in the cylinder by 20.0°C will be :

(Given gas constant $R = 8.3\ JK^{-1}\text{-}mol^{-1}$)

(A) 249 J (B) 415 J

(C) 498 J (D) 830 J

Official Ans. by NTA (C)

Ans. (C)

Sol. No of moles $= \frac{44.8}{22.4} = 2$

Gas is mono atomic so $C_V = \frac{3}{2}R$

$\Delta Q = nC_V\Delta T$

$= 2 \times \frac{3}{2}R(20)$

$= 60\ R$

$= 60 \times 8.3$

$= 498\ J$

6. A wire of length L is hanging from a fixed support. The length changes to L_1 and L_2 when masses 1kg and 2 kg are suspended respectively from its free end. Then the value of L is equal to :

(A) $\sqrt{L_1L_2}$ (B) $\frac{L_1 + L_2}{2}$

(C) $2L_1 - L_2$ (D) $3L_1 - 2L_2$

Official Ans. by NTA (C)

Ans. (C)

Sol. By Hooke's Law

so $F \propto \Delta L$

$\frac{F_1}{F_2} = \frac{\Delta L_1}{\Delta L_2}$

$\frac{10}{20} = \frac{(L_1 - L)}{(L_2 - L)}$

7. Given below are two statements : one is labelled as **Assertion A** and the other is labelled as **Reason R**.

Assertion A : The photoelectric effect does not take place, if the energy of the incident radiation is less than the work function of a metal.

Reason R : Kinetic energy of the photoelectrons is zero, if the energy of the incident radiation is equal to the work function of a metal.

In the light of the above statements, choose the **most appropriate** answer from the options given below.

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

(B) Both **A** and **R** are correct but **R** is not the correct explanation of **A**

(C) **A** is correct but **R** is not correct

(D) **A** is not correct but **R** is correct

Official Ans. by NTA (B)

Ans. (B)

Sol. To free the electron from metal surface minimum energy required, is equal to the work function of that metal.

So Assertion A, is correct.

$h\nu = w_0 + K.E._{max}$

if $h\nu = w_0$

$\Rightarrow K.E._{max} = 0$

Hence reason R, is correct, But R is not the correct explanation of A.

8. A particle of mass 500 gm is moving in a straight line with velocity $\upsilon = b\ x^{5/2}$. The work done by the net force during its displacement from x = 0 to x = 4 m is : (Take $b = 0.25\ m^{-3/2}\ s^{-1}$).

(A) 2 J (B) 4 J (C) 8 J (D) 16 J

Official Ans. by NTA (D)

Ans. (D)

Sol. By work energy theorem

work done by net force = ΔK.E.

$\Rightarrow w = \frac{1}{2}m\upsilon_f^2 - \frac{1}{2}m\upsilon_i^2$

$w = \frac{1}{2} \times 0.5 \times (0.25)^2 \times (4)^5$

$\boxed{w = 16J}$

9. A charged particle moves along circular path in a uniform magnetic field in a cyclotron. The kinetic energy of the charged particle increases to 4 times its initial value. What will be the ratio of new radius to the original radius of circular path of the charged particle :

(A) 1 : 1 (B) 1 : 2

(C) 2 : 1 (D) 1 : 4

Official Ans. by NTA (C)

Ans. (C)

Sol. radius of paerticle in cyclotron

$$r = \frac{\sqrt{2mK.E.}}{qB}$$

So ratio of new radius to original

$$\frac{r_n}{r_0} = \sqrt{\frac{(K.E.)_n}{(K.E)_0}} = \sqrt{4} \Rightarrow 2:1 \ (C)$$

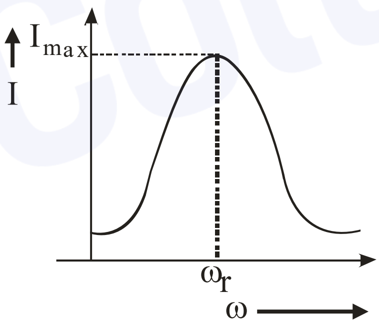
10. For a series LCR circuit, I vs ω curve is shown :

(a) To the left of ω_r, the circuit is mainly capacitive.

(b) To the left of ω_r, the circuit is mainly inductive.

(c) At ω_r, impedance of the circuit is equal to the resistance of the circuit.

(d) At ω_r, impedance of the circuit is 0.



Choose the **most appropriate** answer from the options given below :

(A) (a) and (d) only (B) (b) and (d) only

(C) (a) and (c) only (D) (b) and (c) only

Official Ans. by NTA (C)

Sol. at ω_r, $X_C = X_L$

$$\Rightarrow \frac{1}{\omega_r C} = \omega_r L$$

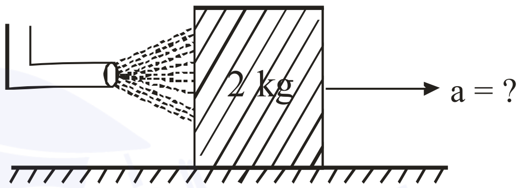
So if $\omega < \omega_r$ then x_C will increase and X_L will decrease.

Hence to left of ω_r circuit is capacitive

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

at ω_r, $Z = \sqrt{R^2 + O^2} = R$ (C)

11. A block of metal weighing 2 kg is resting on a frictionless plane (as shown in figure). It is struck by a jet releasing water at a rate of 1 kgs^{-1} and at a speed of 10 ms^{-1}. Then, the initial acceleration of the block, in ms^{-2}, will be :



(A) 3 (B) 6

(C) 5 (D) 4

Official Ans. by NTA (C)

Ans. (C)

Sol. $F = \frac{dp}{dt} = \upsilon \frac{dm}{dt}$

$\Rightarrow Ma = 10 \times 1$

$\Rightarrow 2a = 10$

$a = 5 m/sec^2$

12. In Vander Waals equation $\left[P + \frac{a}{V^2}\right][V - b] = RT$; P is pressure, V is volume, R is universal gas constant and T is temperature. The ratio of constants $\frac{a}{b}$ is dimensionally equal to :

(A) $\frac{P}{V}$ (B) $\frac{V}{P}$

(C) PV (D) PV^3

Official Ans. by NTA (C)

Ans. (C)

Sol. By principle of homogenity

$[P] = \left[\frac{a}{v^2}\right]$ and $[b] = [v]$

$$\left[\frac{a}{b}\right] = [PV]$$

13. Two vectors $\vec{A}$ $\vec{B}$ ual magnitudes. If magnitude of $\vec{A}+\vec{B}$ is equal to two times the magnitude of $\vec{A}-\vec{B}$, then the angle between $\vec{A}$ and $\vec{B}$ will be :

(A) $\sin^{-1}\left(\frac{3}{5}\right)$ (B) $\sin^{-1}\left(\frac{1}{3}\right)$

(C) $\cos^{-1}\left(\frac{3}{5}\right)$ (D) $\cos^{-1}\left(\frac{1}{3}\right)$

Official Ans. by NTA (C)

Ans. (C)

Sol. $(a^2 + b^2 + 2ab\cos\theta) = 4\,(a^2 + b^2 - 2ab\cos\theta)$

put a = b we get

$2a^2 + 2a^2\cos\theta = 8a^2 - 8a^2\cos\theta$

$\cos\theta = \frac{3}{5}$

14. The escape velocity of a body on a planet 'A' is 12 kms^{-1}. The escape velocity of the body on another planet 'B', whose density is four times and radius is half of the planet 'A', is :

(A) 12 kms^{-1} (B) 24 kms^{-1}

(C) 36 kms^{-1} (D) 6 kms^{-1}

Official Ans. by NTA (A)

Ans. (A)

Sol. $V_{escape} = \sqrt{\frac{2Gm}{R}} \Rightarrow \sqrt{\frac{2G\rho\times\frac{4}{3}\pi R^3}{R}}$

$V_{escape} \propto \sqrt{\rho R^2}$

$\therefore$ if ρ is 4 times and Radius is halved.

$\Rightarrow V_{escape}$ will remain same $\therefore$ Ans (A)

15. At a certain place the angle of dip is 30° and the horizontal component of earth's magnetic field is 0.5 G. The earth's total magnetic field (in G), at that certain place, is :

(A) $\frac{1}{\sqrt{3}}$ (B) $\frac{1}{2}$

(C) $\sqrt{3}$ (D) 1

Official Ans. by NTA (A)

Ans. (A)

Sol. $B_H = B\cos\theta$

$\therefore B = \frac{B_H}{\theta} = \frac{0.5G}{\cos 30°} \Rightarrow \frac{G}{\sqrt{3}}$

16. A longitudinal wave is represented by $x = 10\sin 2\pi\left(nt - \frac{x}{\lambda}\right)$ cm. The maximum particle velocity will be four times the wave velocity if the determined value of wavelength is equal to :

(A) 2π (B) 5π

(C) π (D) $\frac{5\pi}{2}$

Official Ans. by NTA (B)

Ans. (B)

Sol. $V_P \max = 4V_{wave}$

$\omega A = 4\left(\frac{\omega}{k}\right) \Rightarrow A = \frac{4\lambda}{2\pi}$

$\lambda = \frac{2\pi A}{4} \Rightarrow \frac{20\pi}{4} \Rightarrow 5\pi$

17. A parallel plate capacitor filled with a medium of dielectric constant 10, is connected across a battery and is charged. The dielectric slab is replaced by another slab of dielectric constant 15. Then the energy of capacitor will :

(A) increase by 50% (B) decrease by 15%

(C) increase by 25% (D) increase by 33%

Official Ans. by NTA (A)

Ans. (A)

Sol. $E \Rightarrow \frac{1}{2}(KC)v^2$

$\therefore$ % change

$\Rightarrow \frac{\frac{1}{2}K_2CV^2 - \frac{1}{2}K_1CV^2}{\frac{1}{2}K_1CV^2} = \frac{K_2 - K_1}{K_1}\times 100$

$\Rightarrow \frac{15-10}{10}\times 100 = 50\%$

18. A positive charge particle of 100 mg is thrown in opposite direction to a uniform electric field of strength 1×10^5 NC^{-1}. If the charge on the particle is 40 μC and the initial velocity is 200 ms^{-1}, how much distance it will travel before coming to the rest momentarily :

(A) 1 m (B) 5 m

(C) 10 m (D) 0.5 m

Official Ans. by NTA (D)

Ans. (D)

Sol. Distance travelled by particle before stopping

$\frac{V^2}{2a} = S \Rightarrow \frac{v^2m}{2qE} \Rightarrow \frac{(200)^2\times 100\times 10^{-6}}{2\times 40\times 10^{-6}\times 10^5} = 0.5m$

19. Using Young's double slit experiment, a monochromatic light of wavelength 5000 Å produces fringes of fringe width 0.5 mm. If another monochromatic light of wavelength 6000Å is used and the separation between the slits is doubled, then the new fringe width will be :

(A) 0.5 mm (B) 1.0 mm

(C) 0.6 mm (D) 0.3 mm

Official Ans. by NTA (D)

Ans. (D)

Sol. Fringe width $\beta = \frac{D\lambda}{d}$

$\lambda_1 = 5000$ Å

$\beta_1 = \frac{D}{d}(5000 \times 10^{-10}) = 5 \times 10^{-4} m \quad ....(I)$

$\beta_2 = \frac{D}{(2d)}(6000 \times 10^{-10}) = x \text{ (let)} \quad ....(II)$

Divide (II) & (I)

$\frac{\beta_2}{\beta_1} = \frac{3000 \times 10^{-10}}{5000 \times 10^{-10}} = \frac{x}{5 \times 10^{-4}}$

$x = 3 \times 10^{-4}$ m or 0.3 mm

20. Only 2% of the optical source frequency is the available channel bandwidth for an optical communicating system operating at 1000 nm. If an audio signal requires a bandwidth of 8 kHz, how many channels can be accommodated for transmission :

(A) 375×10^7 (B) 75×10^7

(C) 375×10^8 (D) 75×10^9

Official Ans. by NTA (B)

Ans. (B)

Sol. Frequency at 1000 nm = $\frac{3 \times 10}{1000 \times 10^{-9}} \Rightarrow 3 \times 10^{14}$ Hz

available for channel band width

$= \frac{2}{100} \times 3 \times 10^{14} \Rightarrow 6 \times 10^{12}$ Hz

Bandwidth for 1 channel = 8000 Hz

∴ No. of channel

$\frac{6 \times 10^{12}}{8 \times 10^3} \Rightarrow \frac{600}{8} \times 10^7 = 75 \times 10^7$

SECTION-B

1. Two coils require 20 minutes and 60 minutes respectively to produce same amount of heat energy when connected separately to the same source. If they are connected in parallel arrangement to the same source; the time required to produce same amount of heat by the combination of coils, will be__________min.

Official Ans. by NTA (15)

Ans. (15)

Sol. $\frac{dQ}{dt} = i^2R = \frac{V^2}{R}$ (we know)

$\Rightarrow$ In 't' time , $\Delta Q = \left(\frac{V^2}{R}\right)t$

Given that, (for same source, v = same)

$Q_0 = \frac{v^2}{R_1} \times 20 = \frac{V^2}{R_2} \times 60 \quad ....(1)$

$\Rightarrow \boxed{R_2 = 3R_1} \quad .....(ii)$

If they are connected in parallel then

$Req = \frac{R_2R_1}{R_1 + R_2} = \frac{3R_1.R_1}{3R_1 + R_1} = \left(\frac{3R_1}{4}\right)$

To produce same heat, using equation ...(1)

$Q_0 = \frac{V^2}{R_1} \times 20 = \frac{v^2}{\left(\frac{3R_1}{4}\right)} \times t$

$t = \frac{3 \times 20}{4} = 15 \text{min}$

2. The intensity of the light from a bulb incident on a surface is 0.22 W/m^2. The amplitude of the magnetic field in this light-wave is______$\times 10^{-9}$ T.

(Given : Permittivity of vacuum $\epsilon_0 = 8.85 \times 10^{-12} C^2N^{-1}m^{-2}$, speed of light in vacuum c = 3×10^8 ms^{-1})

Official Ans. by NTA (43)

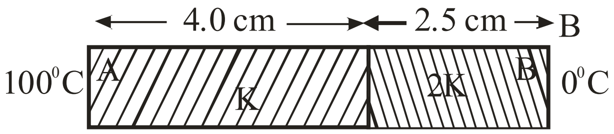
Ans. (43)

Sol. $I = \left(\frac{1}{2}\varepsilon_0 E_0^2\right)C$

$\Rightarrow E_0 \Rightarrow \sqrt{\frac{2I}{\varepsilon_0 C}} \Rightarrow \sqrt{\frac{2 \times 0.22}{8.85 \times 10^{-12} \times 3 \times 10^8}} = 12.873$

$B \Rightarrow \frac{E_0}{C} \Rightarrow \frac{12.873}{3 \times 10^8} = 4.291 \times 10^{-8} = 43 \times 10^{-9}$

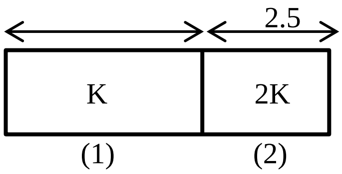
3. As per the given figure, two plates A and B of thermal conductivity K and 2 K are joined together to form a compound plate. The thickness of plates are 4.0 cm and 2.5 cm respectively and the area of cross-section is 120 cm^2 for each plate. The equivalent thermal conductivity of the compound plate is $\left(1+\frac{5}{\alpha}\right)$K, then the value of α will be ________.



Official Ans. by NTA (21)

Ans. (21)

Sol.



$$\frac{\Delta Q}{\Delta t}=\left(\frac{1}{R}\right)\Delta T$$

R : Thermal resistivity

$$\therefore R_1=\frac{L_1}{K_1A}=\frac{L_1}{K(120)}$$

$L_1 = 4$ cm

$A = 120\ cm^2$

$$R_2=\frac{2.5}{(2K)(120)}$$

Now, R_{eq} of this series combination

$R_{eq} = R_1 + R_2$

where $L_{eq} = 4 + 2.5 = 6.5$

$$\frac{L_{eq}}{K_{eq}(A)}=\frac{4}{K(120)}+\frac{5}{\frac{2}{2K(120)}}$$

$$\frac{6.5}{K_{eq}(120)}=\frac{4}{K(120)}+\frac{5}{4K(120)}$$

$$\frac{6.5}{K_{eq}}=\frac{21}{4K}$$

$$K_{eq}=\frac{26}{21}K=\left(1+\frac{5}{21}\right)K$$

4. A body is performing simple harmonic with an amplitude of 10 cm. The velocity of the body was tripled by air Jet when it is at 5 cm from its mean position. The new amplitude of vibration is $\sqrt{x}$ cm. The value of x is__________.

Official Ans. by NTA (700)

Ans. (700)

Sol. A = 10 cm

$$\therefore \text{Total Energy} = \frac{1}{2}KA^2$$

By energy conservation we can final v at x = 5

$$\frac{1}{2}K(10)^2=\frac{1}{2}K(5)^2+\frac{1}{2}mv^2$$

$$V=\sqrt{\frac{75K}{m}}$$

Now, velocity is tripled through external mean so the amplitude of SHM will charge and so the total energy, (but potential) energy at this moment will remain same)

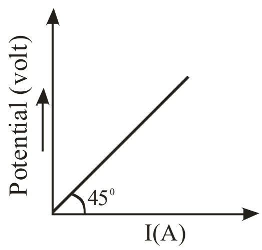
$$\therefore \frac{1}{2}K(5)^2+\frac{1}{2}m\left(3\sqrt{\frac{75K}{m}}\right)^2=\frac{1}{2}KA^2$$

$\Rightarrow 25\ K + 675\ K = KA^2$

$\therefore A=\sqrt{700}$

$\therefore x = 700$

5. The variation of applied potential and current flowing through a given wire is shown in figure. The length of wire is 31.4 cm. The diameter of wire is measured as 2.4 cm. The resistivity of the given wire is measured as x × 10^{-3} Ω cm. The value of x is __________. [Take π = 3.14]



Official Ans. by NTA (144)

Sol. $1 = \rho \frac{\ell}{A}$

$1 = \frac{\rho \times 31.4}{\frac{\pi (2.4)^2}{4}}$

$\frac{\pi (2.4)^2}{4} = \rho \times 314$

$\frac{2.4 \times 2.4}{4} = \rho \times 10$

$\frac{0.6 \times 2.4}{10} = \rho$

$\frac{1.44}{10} = \rho$

$0.144 = \rho$

$144 \times 10^{-3} = \rho$

6. 300 cal. of heat is given to a heat engine and it rejects 225 cal. of heat. If source temperature is 227°C, then the temperature of sink will be __ ^{0}C.

Official Ans. by NTA (102)

Ans. (102)

Sol. $1 - \frac{Q_2}{Q_1} = 1 - \frac{T_2}{T_1}$

$\frac{Q_2}{Q_1} = \frac{T_2}{T_1}$

$\frac{225}{300} = \frac{T_2}{500}$

$\frac{500 \times 225}{300} = T_2$

$375 = T_2$

$102°C = T_2$

7. $\sqrt{d_1}$ and $\sqrt{d_2}$ are the impact parameters corresponding to scattering angles 60° and 90° respectively, when an α particle is approaching a gold nucleus. For $d_1 = x\, d_2$, the value of x will be_______.

Official Ans. by NTA (3)

Ans. (3)

Sol. $\sqrt{d} \propto \cot \frac{\theta}{2}$

$\cot^2 30° = x \cot^2 45°$

8. A transistor is used in an amplifier circuit in common emitter mode. If the base current changes by 100 μA, it brings a change of 10 mA in collector current. If the load resistance is 2 kΩ and input resistance is 1 kΩ, the value of power gain is $x \times 10^4$. The value of x is _______.

Official Ans. by NTA (2)

Ans. (2)

Sol. $\Delta i_B = 100\ \mu A$ $\qquad \beta = \frac{\Delta i_C}{\Delta i_B}$

$\Delta i_C = 10\ mA$

$\text{power} = \beta^2 \times \frac{R_0}{R_{in}}$

$\text{Power} = \left(\frac{10}{0.1}\right)^2 \times \frac{2}{1}$

$\text{Power} = 100 \times 100 \times 2$

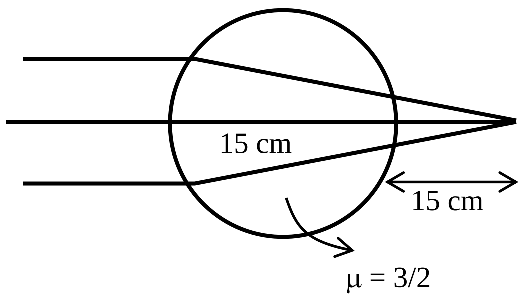
$\text{Gain} = 2 \times 10^4$

9. A parallel beam of light is allowed to fall on a transparent spherical globe of diameter 30 cm and refractive index 1.5. The distance from the centre of the globe at which the beam of light can converge is _________ mm.

Official Ans. by NTA (225)

Ans. (225)

Sol.



$\frac{\frac{3}{2}}{V} - \frac{1}{\infty} = \frac{\frac{3}{2} - 1}{15}$

$\frac{3}{2V} = \frac{1}{30}$

$V = 45\ cm$

$$\frac{1}{V}-\frac{3}{\frac{2}{15}}=\frac{1-\frac{3}{2}}{\frac{2}{-15}}$$

$$\frac{1}{V}-\frac{1}{10}=\frac{1}{30}$$

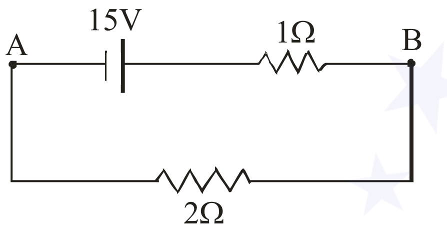
$$\frac{1}{V}=\frac{1}{10}+\frac{1}{30}=\frac{4}{30}$$

$$\boxed{V=7.5}$$

$$\boxed{V=22.5}$$

v = 225 mm

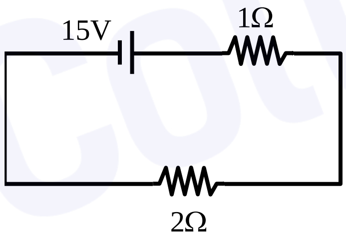
10. For the network shown below, the value $V_B - V_A$ is ________V.



Official Ans. by NTA (10)

Ans. (10)

Sol.



$$i=\frac{15}{3}=5A$$

15 – 5 (1) = 10 Volt