JEE Main March 2021

Question Paper With Text Solution

18 March. | Shift-2

PHYSICS

MATRIX

JEE Main & Advanced | XI-XII Foundation| VI-X Pre-Foundation

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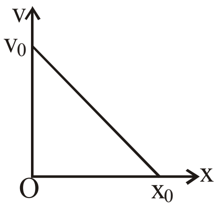
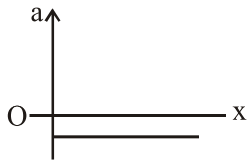
JEE MAIN MARCH 2021 | 18TH MARCH SHIFT-2

SECTION – A

1. The velocity -displacement graph of a particle is shown in the figure.



The acceleration -displamcement graph of the same particle is represented by :

(1)


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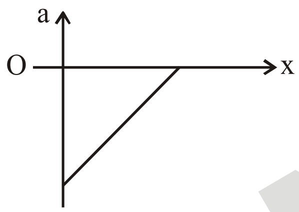

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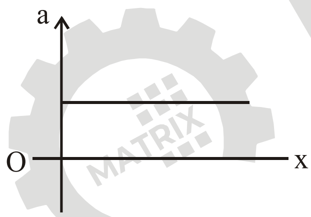

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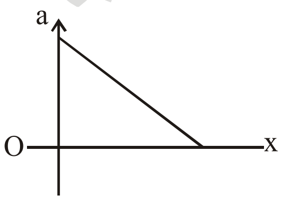


Ans. Official Answer by NTA (2)

Sol. We cam write $V(x) = -\left(\frac{V_0}{x_0}\right)x + V_0$

$$a = \frac{VdV}{dX} = \left(\frac{-V_0}{x_0}x + V_0\right)\left(\frac{-V_0}{x_0}\right)$$

$$a = \left(\frac{V_0}{x_0}\right)^2 x - \frac{V_0^2}{x_0}$$

Slope of a V/s x will be positive

2. The decay of a proton to neutron is :

(1) Not possible as proton mass is less than the neutron mass

(2) Always possible as it is associated only with β^+ decay

(3) Not possible but neutron to proton conversion is possible

(4) Possible only inside the nucleus

Ans. Official Answer by NTA (4)

Sol. Decay of a proton to neutron is possible only inside the nucleus
Ans. 4

3. A proton and an α-particle, is 2 : 1. The ratio $K_p : k_\alpha$ is:

(1) 4 : 1

(2) 1 : 8

(3) 1 : 4

(4) 8 : 1

Ans. Official Answer by NTA (1)

Sol. Radius = R = $\frac{mV}{qB} = \frac{\sqrt{2mE}}{qB}$

E $\rightarrow$ kinetic energy

$$\frac{R_P}{R_\alpha} = \frac{\frac{\sqrt{mK_P}}{e}}{\frac{\sqrt{4mK_\alpha}}{2e}} = \frac{2}{1}$$

$$\frac{K_P}{K_\alpha} = \frac{4}{1}$$

4. An object of mass m_1 collides with another object of mass m_2, which is at rest. After the collision the objects move with equal speeds in opposite direction. The ratio of the masses $m_2 : m_1$ is :

(1) 1 : 2

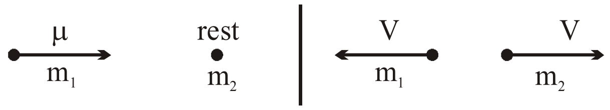
(2) 3 : 1

(3) 2 : 1

(4) 1 : 1

Ans. Official Answer by NTA (2)

Sol.



$P_i = P_f \Rightarrow \; m_1u + 0 = -\,m_1V + m_2V$

$m_1u = (m_2 - m_1)V$ ....(1)

$e = \dfrac{V-(-V)}{u-0} = \dfrac{2V}{u}$

Condition force $0 \le e \le 1$

$$0 \le \frac{2V}{u} \le 1$$

$$0 \le \frac{V}{u} \le \frac{1}{2}$$

from eq (1) $\dfrac{m_1}{m_2 - m_1} \le \dfrac{1}{2}$

$$2m_1 \le m_2 - m_1$$

$$3m_1 \le m_2$$

$$\frac{m_2}{m_1} \ge 3$$

5. For an adiabatic expansion of an ideal gas, the fractional change in its pressure is equal to (where γ is the ratio of specific heats) :

(1) $\dfrac{dV}{V}$

(2) $-\gamma\dfrac{dV}{V}$

(3) $-\gamma\dfrac{V}{dV}$

(4) $-\frac{1}{\gamma}\frac{dV}{V}$

Ans. Official Answer by NTA (2)

Sol. For adiabatic process $PV^{\gamma} = K$

So

$$\frac{\Delta P}{P} + \frac{\gamma \Delta V}{V} = 0$$

Fraction change in pressur $= \frac{\Delta P}{P} = \frac{-\gamma \Delta V}{V}$

6. Consider a uniform wire of mass M and length L. It is bent into a semicircle. Its moment of inertia about a line perpendicular to the plane of the wire passing through the centre is :

(1) $\frac{1}{4}\frac{ML^2}{\pi^2}$

(2) $\frac{1}{2}\frac{ML^2}{\pi^2}$

(3) $\frac{2}{5}\frac{ML^2}{\pi^2}$

(4) $\frac{ML^2}{\pi^2}$

Ans. Official Answer by NTA (4)

Sol. Length of wire = half of circumference of wire

$L = \pi R \Rightarrow R = \frac{L}{\pi}$

MOI of element $= dmR^2$

$$dI = dm\left(\frac{L}{\pi}\right)^2$$

$$I = \int dI = \int dm\left(\frac{L}{\pi}\right)^2 = \frac{ML^2}{\pi^2}$$

7. A plane electromagnetic wave propagating along y-direction can have the following pair of electric field $(\vec{E})$ and magnetic field $(\vec{B})$ components.

(1) E_x, B_y or E_y, B_x

(2) E_x, B_z or E_z, B_x

(3) E_y, B_y or E_x, B_y

(4) E_y, B_y or E_z, B_z

Ans. Official Answer by NTA (2)

Sol. Electric field $(\vec{E})$, magnetic field $(\vec{B})$ and wave propagation vectors are perpendiaular to each other.
If wave propagation vector in y
then (i) $\vec{E}$ in x dir^n and $\vec{B}$ in z dir^n
or (ii) $\vec{E}$ in z dir^n and $\vec{B}$ in x dir^n

8. A solid cylinder of mass m is wrapped with an inextensible light string and, is placed on a rough inclined plane as shown in the figure. The frictional force acting between the cylinder and the inclined plane is :

[The coefficient of static friction, μ_s, is 0.4]

(1) $\frac{mg}{5}$

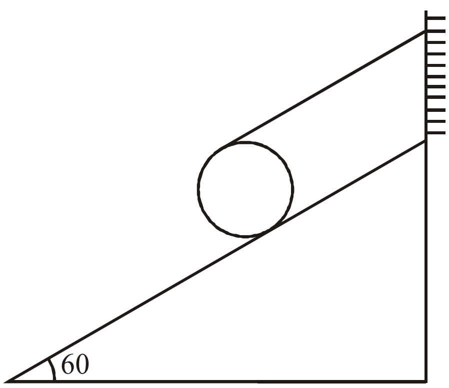
(2) $\frac{7}{2}mg$

(3) 5 mg

(4) 0

Ans. Official Answer by NTA (1)

Sol.



first take cylindes in eqb^m then
$T + f = mg \sin 60$ ....(1)

$\tau_A = 0 \Rightarrow$ mg sin 60 (R) = T(2R) ....(2)

$$T = \frac{mg\sin 60}{2}$$

from (1) & (2) $f = \frac{mg\sin 60}{2}$

$(f_S)_{max} = \mu_S N = (0.4)$ (mg cos 60)

$f > (f_S)_{max}$ = so object not in eqb^m

then friction = $f_K = (0.4)\ mg\cos 60 = \frac{mg}{5}$

9. Which of the following statements are correct ?

(A) Electric monopoles do not exist whereas magnetic monopoles exist.

(B) Magnetic field lines due to a solenoid at its ends and outside cannot be completely straight and confined.

(C) Maganetic field lines are completely confined within a toroid.

(D) Magnetic field lines inside a bar magnet are not parallel.

(E) $x = -1$ is the condition for a perfect diamagnetic material, where x is its magnetic susceptibility.

Choose the correct answer from the options given below :

(1) (B) and (D) only

(2) (A) and (B) only

(3) (C) and (E) only

(4) (B) and (C) only

Ans. Official Answer by NTA (3)

Sol. (A) Electric and magnetic monopoles exist.

(B) Magnetic field outside solenoid is zero.

(C) Maganetic field only inside the toroid.

(D) Magnetic field lines inside a bar magnet are parallel.

(E) For diamagnetic material $x = -1$

10. In a series LCR circuit, the inductive reacctance (X_L) is 10Ω and the capacitive reactance (X_C) is 4Ω. The resistance (R) in the circuit is 6Ω.

The power factor of the circuit is :

(1) $\frac{1}{2\sqrt{2}}$

(2) $\frac{\sqrt{3}}{2}$

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

(4) $\frac{1}{2}$

Ans. Official Answer by NTA (3)

Sol. Power factor $\cos\phi = \frac{R}{z} = \frac{R}{\sqrt{R^2 + (X_C - X_L)^2}}$

$$= \frac{6}{\sqrt{6^2 + (10-4)^2}} = \frac{6}{\sqrt{2}\times 6} = \frac{1}{\sqrt{2}}$$

11. If the angular velocity of earth's spin is increased such that the bodies at the equator start floating, the duration of the day would be approximately :

[Take = g 10 ms^{-2}, the radius of earth, R = 6400 × 10^{3}m, Take π = 3.14]

(1) 84 minutes

(2) 1200 minutes

(3) does not change

(4) 60 minutes

Ans. Official Answer by NTA (1)

Sol. For object o float mg = mω^2R

$$\omega = \sqrt{\frac{g}{R}}$$

$$T = \frac{2\pi}{\omega} = 2\pi\sqrt{\frac{R}{g}}$$

$$T = 2\pi\sqrt{\frac{6400\times 10^3}{10}} \text{ sec}$$

$T = \frac{2\pi}{60}\sqrt{6400 \times 100}$ min

T = 84 min

12. Consider a sample of oxygen behaving like an ideal gas. At 300K, the ratio of root mean square (rms) velocity to the average velocity of gas molecule would be :

(Molecular weight of oxygen is 32g/mol; R = 8.3 J k^{-1} mol^{-1})

(1) $\sqrt{\frac{8}{3}}$

(2) $\sqrt{\frac{8\pi}{3}}$

(3) $\sqrt{\frac{3\pi}{8}}$

(4) $\sqrt{\frac{3}{3}}$

Ans. Official Answer by NTA (3)

Sol. $V_{rms} = \sqrt{\frac{3RT}{M}}$ $\qquad V_{av} = \sqrt{\frac{8RT}{\pi M}}$

$\frac{V_{rms}}{V_{av}} = \sqrt{\frac{3\pi}{8}}$

13. The time taken for the magnetic energy to reach 25% of its maximum value, when a solenoid of resistance R, inductance L is connected to a battery, is :

(1) $\frac{L}{R}\ln 10$

(2) $\frac{L}{R}\ln 2$

(3) $\frac{L}{R}\ln 5$

(4) infinite

Ans. Official Answer by NTA (2)

Sol. Magnetic energy stored in inductor $=\frac{1}{2}LI^2$

$(E)_{max}=\frac{1}{2}L(I_0)^2$ I_0 = maximum current

$E = 25\% \ E_{max}$

$\frac{1}{2}LI^2=\frac{25}{100}\left(\frac{1}{2}LI_0^2\right)$

$I=\frac{I_0}{2}$

Charging eq. of inductor $\Rightarrow I = I_0((1-e^{-Rt/L})$

$\frac{I_0}{2}=I_0\left(1-e^{-Rt/L}\right)$

$e^{-Rt/L}=1/2$

$\frac{Rt}{L}=\ell n2$

$t=\frac{L}{R}\ell n2$

14. The speed of electrons in a scanning electron microscope is 1×10^7 ms^{-1}. If the protons having the same speed are used instead of electrons, then the resolving power of scanning proton microscope will be changed by a factor of :

(1) $\sqrt{1837}$

(2) $\frac{1}{1837}$

(3) 1837

(4) $\frac{1}{\sqrt{1837}}$

Ans. Official Answer by NTA (3)

Sol. Resolving power $\propto\frac{1}{\lambda}$ $\lambda=\frac{h}{mV}$

$RP \propto mV$

$RP \propto m$ velocity is same

$\frac{RP_e}{RP_P}=\frac{m}{1837m}$

$RP_P = 1837\ RP_e$

15. The function of time representing a simple harmonic motion with a period of $\frac{\pi}{\omega}$ is :

(1) $\cos(\omega t)+\cos(2\omega t)+\cos(3\omega t)$

(2) $\sin(\omega t)+\cos(\omega t)$

(3) $3\cos\left(\frac{\pi}{4}-2\omega t\right)$

(4) $\sin^2(\omega t)$

Ans. Official Answer by NTA (3)

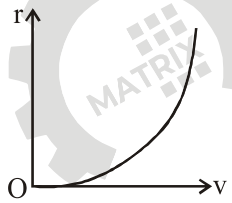
Sol. $T=\frac{2\pi}{\omega^1}=\frac{\pi}{\omega}\Rightarrow \omega^1 = 2\omega$

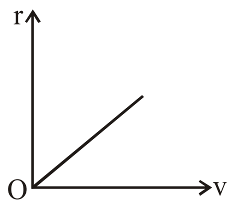
<u>option 3</u> $3\cos\left(\frac{\pi}{4}-2\pi t\right)$

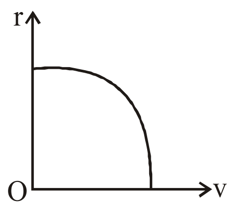
$\omega^1 = 2\omega$

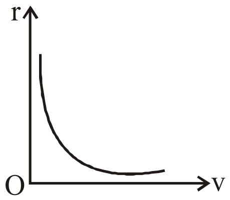
16. A particle of mass m moves in a circular orbit under the central potential field, U(r) = $-\frac{C}{r}$, where C is a positive constant.

The correct radius – velocity graph of the particle's motion is :

(1) 

(2) 

(3) 

(4) 

Ans. Official Answer by NTA (4)

Sol. $U = \frac{-C}{r}$ $F = \frac{-dU}{dr} = -\left(\frac{+C}{r^2}\right)$

$F = \frac{-C}{r^2}$

$\frac{C}{r^2} = \frac{mv^2}{r} \Rightarrow V^2 \propto r$

17. The correct relation between α (ratio of collector current to emitter current) and β (ratio of collector current to base current) of a transistor is :

(1) $\beta = \frac{1}{1-\alpha}$

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

(3) $\alpha = \frac{\beta}{1-\alpha}$

(4) $\beta = \frac{\alpha}{1+\alpha}$

Ans. Official Answer by NTA (2)

Sol. $\alpha = \frac{I_C}{I_E}$ $\beta = \frac{I_C}{I_B}$

and $I_E = I_B + I_C$

from these relaton

$\alpha = \frac{\beta}{1+\beta}$

18. The angular momentum of a planet of mass M moving around the sun in an elliptical orbit is $\vec{L}$. The magnitude of the areal velocity of the planet is :

(1) $\frac{L}{M}$

(2) $\frac{2L}{M}$

(3) $\frac{L}{2M}$

(4) $\frac{4L}{M}$

Ans. Official Answer by NTA (1)

Sol. $\frac{dA}{dt}=\frac{L}{2m}$

Ans. 3

19. An ideal gas in cylinder is separated by a piston in such a way that the entropy of one part is S_1 and that of the other part is S_2. Given that $S_1 > S_2$. If the piston is removed then the total entropy of the system will be :

(1) $S_1 - S_2$

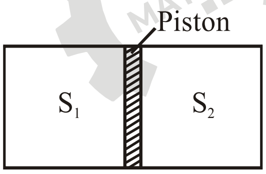
(2) $S_1 \times S_2$

(3) $S_1 + S_2$

(4) $\frac{S_1}{S_2}$

Ans. Official Answer by NTA (3)

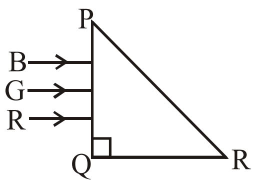
Sol.



If the piston is removed then $S_{total} = S_1 + S_2$

Ans. 3

20. Three rays of light, namely red (R), green (G) and blue (B) are incident on the face PQ of a right angled prism PQR as shown in the figure.



The refractive indices of the material fo the prism for red, green and blue wavelength are 1.27, 1.42 and 1.49 respectively. The colour of the ray(s) emerging out of the face PR is :

(1) Blue and Green

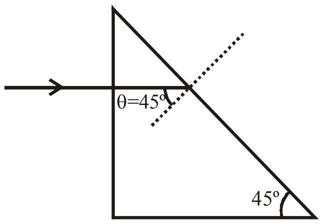
(2) Red

(3) Green

(4) Blue

Ans. Official Answer by NTA (2)

Sol.



Assume right angled prism is an isosceles so $\theta = 45^o$

Critical angle $= \theta_C = \sin^{-1}\left(\frac{1}{\mu}\right)$

The wavelength corresponding to which the incidence angle is less than the critical angle, will pass through PR..

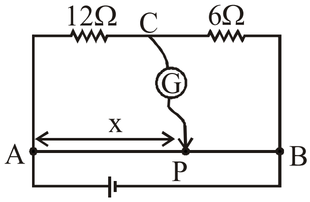
$(\theta_C)_{Red} = \sin^{-1}\left(\frac{1}{1.24}\right) \approx 52$ Red will pass

$(\theta_C)_{Green} = \sin^{-1}\left(\frac{1}{1.42}\right) \approx 44$ Red will not pass

$(\theta_C)_{Blue} = \sin^{-1}\left(\frac{1}{1.49}\right) \approx 42$ Blue will not pass

Section B

1. Consider a 72 cm long wire AB as shown in the figure. The galvanometer jockey is placed at P on AB at a distance x cm from A. The galvanometer shows zero deflection.

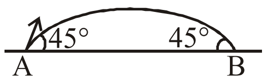


The value of x, to the nearest integer, is _____ .

Ans. Official Answer by NTA (48)

Sol. (12) (72 – x) = 6 (x)
x = 48 cm.

2. The projectile motion of a particle of mass 5g is shown in the figure.



The initial velocity of the particle is $5\sqrt{2}\text{ms}^{-1}$ and the air resistance is assumed to be negligible.
The magnitude of the change in momentum between the points A and B is $x \times 10^{-2}\text{kgms}^{-1}$
The value of x, to the nearest integer, is_______.

Ans. Official Answer by NTA (5)

Sol. no momentum change in x direction, momentum will change in only y direction.

$$\Delta P = \left[-\left(5\sqrt{2}\sin 45\right) - \left(5\sqrt{2}\sin 45\right)\right]m$$

$$|\Delta P| = (2)(5)\left(\sqrt{2}\right)\left(\frac{1}{\sqrt{2}}\right)\frac{5}{1000} = 5\times10^{-2}$$

x = 5

3. An inifinite number of point charges, each carrying $1\mu C$ charge, are placed along the y-axis at y=1 m, 2m, 4m, 8m ______ .
The total force on a 1 C point charge, placed at the origin, is x × 10^3N.
The value of x, to the nearest integer, is _____.

[Take $\frac{1}{4\pi\varepsilon_0} = 9\times10^9 \text{Nm}^2/\text{C}^2$]

Ans. Official Answer by NTA (12)

Sol. 1C at origin, $1\mu C$ at y=1, $1\mu C$ at y=2, $1\mu C$ at y=4 ----- y axix

Force on $1C = \frac{K(1)(1\times10^{-6})}{(1)^2} + \frac{K(1)(1\times10^{-6})}{(2)^2}$

$+\frac{K(1)(1\times10^{-6})}{4^2}$ ----------

$= K\left(1\times10^{-6}\right)\left[1+\frac{1}{2^2}+\frac{1}{4^2}+\frac{1}{8^2}........\right]$

$= 9\times10^{9}\times10^{-6}\left[1+\frac{1}{4}+\frac{1}{16}+\frac{1}{64}........\right]$ GP of infinite term

$= 9\times10^{3}\left[\frac{1}{1-1/4}\right] = \frac{9\times4\times10^{3}}{3}$

$= 12 \times 10^{3}$

$x = 12$

4. The wires of same length and thickness having specific resistances 6Ω cm and 3Ω cm respectively are connected in parallel. The effective resistivity is $\rho\Omega$ cm. The value of ρ, to the nearest integer, is____.

Ans. Official Answer by NTA (4)

Sol. $Req = \frac{R_1R_2}{R_1+R_2}$

$$\frac{\rho\ell}{2A} = \frac{\frac{\rho_1\ell}{A}\times\frac{\rho_2\ell}{A}}{\frac{\rho_1\ell}{A}+\frac{\rho_2\ell}{A}}$$

$\frac{\rho}{2} = \frac{6\times3}{6+3} \quad \Rightarrow \rho = 4$

5. A galaxy is moving away from the earth at a speed of 286 kms^{-1}. The shift in the wavelength of a redline at 630 nm is $x \times 10^{-10}$ m.

The value of x, to the nearest integer, is____.

[Take the value of speed of light c, as 3×10^{8} ms^{-1}]

Ans. Official Answer by NTA (6)

Sol. $\frac{\Delta\lambda}{\lambda}C = V$

$$\Delta\lambda = \frac{V\lambda}{C} = \frac{286\times1000\times630\times10^{-9}}{3\times10^{8}}$$
$$= 6 \times 10^{-10}$$

$x = 6$

6. A ball of mass 4 kg, moving with a velocity of 10 ms^{-1}, collides with a spring of length 8 m and force constant 100 Nm^{-1}.The length of the compressed spring is x m. The value of x, to the nearest integer, is___ .

Ans. Official Answer by NTA (6)

Sol. $w_{sp} = \Delta KE$

$$\frac{K}{2}\left[0^2 - x^2\right] = 0 - \frac{1}{2}mV^2$$

$$\frac{100}{2}x^2 = \frac{1}{2}\times(4)(10)^2$$

$$x = \frac{2\times10}{10} = 2m$$

x is maximum compression in spring

so length of spring = 8 – 2 = 6 m

7. The radius of a sphere is measured to be(7.50 $\pm$ 0.85) cm. Suppose the percentage error in its volume is x.

The value of x, to the nearest x, is______.

Ans. Official Answer by NTA (34)

Sol. $V = \frac{4}{3}\pi R^3$

$$\frac{\Delta V}{V} = \frac{3\Delta R}{R}$$

$$\frac{\Delta V}{V} = \frac{3\times0.85}{7.5}$$

$$\frac{\Delta V}{V}\% = \frac{3\times0.85}{7.5}\times100$$
$$= 34\%$$

$x = 34$

8. A TV transmission tower antenna is at a height of 20m. Suppose that the receiving antenna is at .

(i) Ground level

(ii) A height of 5 m.

The increase in antenna range in case (ii) relative to case (i) is n%.

The value of n, to the nearest integer, is____.

Ans. Official Answer by NTA (50)

Sol. Range in case (1) $= \sqrt{2Rh} = \sqrt{2(R)(20)}$

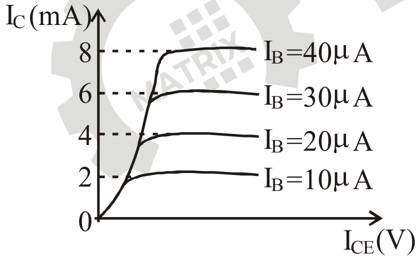
Range in case (2) $= \sqrt{2Rh} + \sqrt{2Rh^1}$

$= \sqrt{2(R)(20)} + \sqrt{(2)(R)(S)}$

$$\frac{\Delta R}{R_1} = \frac{\sqrt{2Rh^1}}{\sqrt{2Rh}}$$

$$\frac{\Delta R\%}{R_1} = \frac{\sqrt{5}}{\sqrt{20}} \times 100 = 50\%$$

9. The typical output characteristics curve for a transistor working in the common-emitter configuration is shown in the figure.



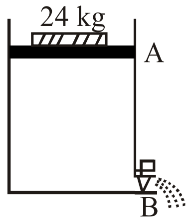
The estimated current gain from the figure is ____ .

Ans. Official Answer by NTA (200)

Sol. Current gain $\beta = \frac{\Delta I_C}{\Delta I_B} = \frac{2\times 10^{-3}}{10\times 10^{-6}} = 200$

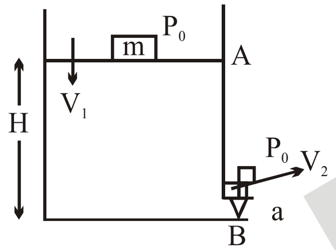
10. Consider a water tank as shown in the figure. It's cross-sectional area is 0.4 m^2. The tank has an opening B near the bottom whose cross-section area is 1cm^2. A load of 24 kg is applied on the water at the top when the height of the water level is 40 cm above the bottom, the velocity of water coming out the nearest integer, is____.

[Take value of g be 10 ms^{-2}]



Ans. Official Answer by NTA (3)

Sol.



Apply Bernoulli's theorem at A & B

$$\left(P_0 + \frac{mg}{A}\right) + \rho gH + \frac{1}{2}\rho V_1^2$$

$$= P_0 + 0 + \frac{1}{2}\rho V_2^2$$

A >> a So $V_1 \approx 0$

$$\left(P_0 + \frac{mg}{A}\right) + \rho gH = P_0 + \frac{1}{2}\rho V_2^2$$

$$\frac{mg}{A} + \rho gH = \frac{\rho}{2}V_2^2$$

$$V_2 = \sqrt{2gH + \frac{2mg}{\rho A}}$$

$$= \sqrt{\frac{2\times10\times40}{100} + \frac{2\times24\times10}{0.4\times1000}}$$

$$V_2 = \sqrt{8+1.2} = 3.033$$

$$V_2 \approx 3m/s$$