JEE-MAIN-2021 (16TH March- second Shift)

PART – A (PHYSICS)

SECTION - A

(One Options Correct Type)

***Questions*: 1:-** A mosquito is moving with a velocity $\bar{v} = 0.5t^2\,\hat{\imath} + 3t\hat{\jmath} + 9\hat{k}$ m/s and accelerating in uniform conditions. What will be the direction of mosquito after 2s?

(A) $\tan^{-1}\left(\frac{2}{3}\right)$ form x – axis

(B) $\tan^{-1}\left(\frac{5}{2}\right)$ form y – axis

(C) $\tan^{-1}\left(\frac{5}{2}\right)$ form x – axis

(D) $\tan^{-1}\left(\frac{2}{3}\right)$ form y – axis

***Ans*:-** $\vec{v} = 0.5t^2\hat{\imath} + 3t\hat{\jmath} + 9\hat{k}\ \text{m/s} \Rightarrow \vec{a} = \frac{d\vec{v}}{dt} = (t\hat{\imath} + 3\hat{\jmath})\ \text{m/s}^2$

At $t = 2$ sec, $\vec{v} = 2\hat{\imath} + 6\hat{\jmath} + 9\hat{k}\ \text{m/s}$ and $\vec{a} = (2\hat{\imath} + 3\hat{\jmath})\ \text{m/s}^2$

If we write the direction of acceleration of mosquito after 2s, then it will be $\tan^{-1}\left(\frac{2}{3}\right)$ from y-axis

***Questions*: 2:-** In order to determine the young's modulus of a wire of radius 0.2 cm (measured using a scale of least count = 0.001 cm) and length 1m (measured using a scale of least count = 1 mm), a weight of mass 1 kg (measured using a scale of least count = 1g) was hanged to get the elongation of 0.5 cm (measured using a scale of least count 0.001 cm.) What will be the fractional error in the value of young's modulus determined by this experiment?

(A) 9%

(B) 0.9%

(C) 0.14%

(D) 1.4%

***Ans*:-** Using hook's law:

$\sigma = Y\varepsilon$

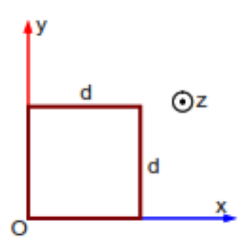
$\Rightarrow \frac{f}{A} = Y\frac{x}{\ell} \Rightarrow Y = \frac{f\ell}{xA} = \frac{f\ell}{x\pi r^2}$

Using error analysis formula:

$\Rightarrow \frac{\Delta Y}{Y} = \frac{\Delta f}{f} + \frac{\Delta \ell}{\ell} + \frac{\Delta x}{x} + 2\frac{\Delta r}{r}$

$\Rightarrow \%\ \text{error in Y} = \left[\frac{1}{1000} + \frac{1}{1000} + \frac{0.001}{0.5} + \frac{2\times 0.001}{0.2}\right] \times 100 = 1.4\%$

***Questions*: 3:-** The magnetic field in a region is given by $\bar{B} = B_0\left(\frac{x}{a}\right)\hat{k}$. A square loop of side d is placed with its edges along the x and y axes. The loop is moved with a constant velocity $\bar{v} = v_0$. The emf induced in the loop is:



(A) $\frac{B_0 v_0 d^2}{a}$

(B) $\frac{B_0 v_0 d}{2a}$

(C) $\frac{B_0 v_0^2 d^2}{2a}$

(D) $\frac{B_0 v_0 d^2}{2a}$

Ans:- Since $\vec{B}, \vec{v}$ and length are perpendicular

$\varepsilon = Bv\ell$

emf will induce only in wire CD

$\varepsilon = B_0\left(\frac{d}{a}\right)v_0(d) = \frac{B_0 v_0 d^2}{a}$

***Questions*: 4:-** Calculate the value of mean free path (λ) for oxygen molecules at temperature 27^0 C and pressure 1.01 x 10^5 Pa. Assume the molecular diameter 0.3 nm and the gas is ideal. (k = 1.38 x $10^{-23}JK^{-1}$)

(A) 58 nm (B) 86 nm

(C) 32 nm **(D) 102 nm**

Ans:- $\lambda = \frac{kT}{\sqrt{2}\pi d^2 P} = \frac{1.38\times10^{-23}\times300}{1.4\times3.14\times(0.3\times10^{-9})^2\times1.01\times10^5} = 102$ nm

***Questions*: 5:-** Calculate the time interval between 33% decay and 67% decay if half-life of a substance is 20 minutes.

(A) 13 minutes (B) 60 minutes

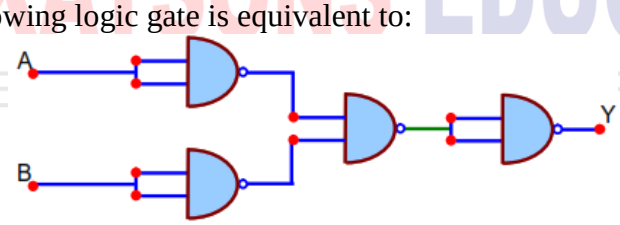
(C) 40 minutes **(D) 20 minutes**

Ans:- $\frac{N_1}{N_0} = e^{-\lambda t} \Rightarrow \frac{2}{3} = e^{-\lambda t} \Rightarrow t_1 = \frac{1}{\lambda}\ell n\left(\frac{3}{2}\right)$

Similarly we can write $t_2 = \frac{1}{\lambda}\ell n(3)$

$\Delta t = t_2 - t_1 = \frac{1}{\lambda}\left[\ell n(3) - \ell n\left(\frac{3}{2}\right)\right] = \frac{\ell n(2)}{\lambda} = T_{\frac{1}{2}} = 20$ min

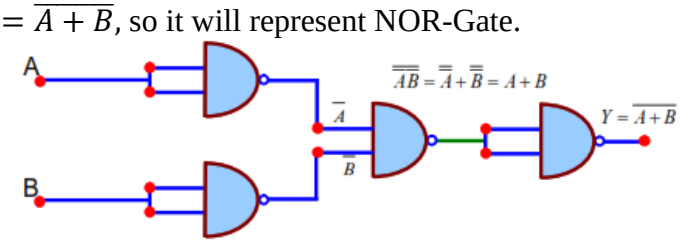
***Questions*: 6:-** The following logic gate is equivalent to:



(A) NAND Gate (B) AND Gate

(C) NOR Gate (D) OR Gate

Ans:- Since output $Y = \overline{A + B}$, so it will represent NOR-Gate.



***Questions*: 7:-** Red light differs from blue light as they have:

(A) Different frequencies and same wavelengths

(B) Same frequencies and same wavelengths

(C) Same frequencies and different wavelengths

(D) Different frequencies and different wavelengths

Ans:- Since speed of light is constant for all colour so red colour and blue colour have different frequencies and different wavelengths

***Questions*: 8:-** What will be the nature of flow of water form a circular tap, when its flow rate increased from 0.18L/min to 0.48L/min? The radius of the tap and viscosity of water are 0.5 cm and 10^{-3} Pa s, respectively.
(Density of water: 10^3 kg/m^3)

(A) Remains steady flow
(B) Unsteady to steady flow
(C) Remains turbulent flow
(D) Steady flow to unsteady flow

***Ans*:- As we know that Reynolds's number** $R = \frac{\rho v D}{\eta}$

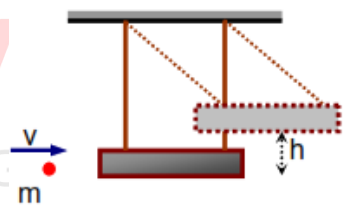
In First case $v_1 = \frac{0.18\times10^{-3}}{\pi\times(0.5\times10^{-2})^2\times60} = \frac{0.18\times10^{-3}\times10^6\times4}{\pi\times25\times60\times4} = \frac{0.18\times4}{\pi\times6} = 0.03822\ \text{m/s}$

$R = \frac{0.03822\times10^3\times0.1}{10^{-3}} = 3822 < 4000 \Rightarrow \text{Steady}$

In Second case $v_2 = \frac{0.48\times10^{-3}}{\pi\times(0.5\times10^{-2})^2\times60} = \frac{0.48\times10^{-3}\times10^6\times4}{\pi\times25\times60\times4} = \frac{0.48\times4}{\pi\times6} = 0.10191\ \text{m/s}$

$R_2 = \frac{0.10191\times10^3\times0.1}{10^{-3}} = 10191 > 4000 \Rightarrow \text{Turbulent}$

***Questions*: 9:-** A large block of wood of mass M = 5.99kg is hanging form two long massless cords. A bullet of mass m = 10 g is fired into the block and gets embedded in it. The (block + bullet) then swing upwards, their centre of mass rising a vertical distance h = 9.8cm before the (block + bullet) pendulum comes momentarily to rest at the end of its arc. The speed of the bullet just before collision is:
(take g = 9.8ms^{-2})



(A) 821.4 m/s
(B) 811.4 m/s
(C) 831.4 m/s
(D) 841.4 m/s

***Ans*:- Using conservation of IInear momentum, we can write**

$P_l = P_t \Rightarrow mv = M(m + m)v'$

Using conservation of Mechanical energy, we can write

$\frac{1}{2}(M + m)(v')^2 = (M + m)gh \Rightarrow \frac{1}{2}\left(\frac{mv}{M+m}\right)^2 = gh$

$\Rightarrow v = \frac{M+m}{m}\sqrt{2gh} = \frac{6}{10\times10^{-3}}\sqrt{2\times9.8\times0.098} = \frac{6}{10\times10^{-3}}\sqrt{2\times\frac{98}{10}\times\frac{98}{1000}}$

$\Rightarrow v = \frac{6\times98\times1.414}{10\times10^{-3}\times10^2} = 831.432\ \text{m/s} \approx 831.4\ \text{m/s}$

***Questions*: 10:-** A charge Q is moving $d\bar{\ell}$ distance in the magnetic field $\bar{B}$. Find the value of work done by $\bar{B}$.

(A) 1
(B) Zero
(C) Infinite
(D) - 1

***Ans*:-** As we know that magnetic force acting on a charge particle will be

$\bar{F} = q(\bar{v}\times\bar{B})$

$W = \bar{F}.d\bar{\ell}$

Since force and displacement will be always perpendicular so work done is always zero.

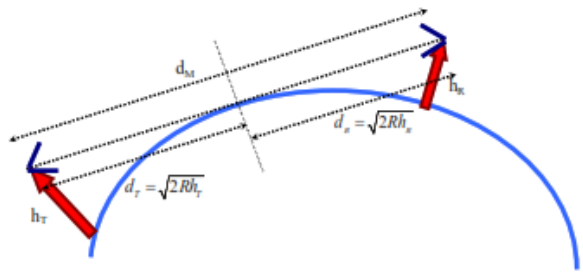
***Questions*: 11:-** Two identical antennas on identical towers are separated from each other by a distance of 45 km. What should be the minimum height of receiving antenna to receive the signals in line of sight?
(Assume radius of earth is 6400 km)

(A) 79.1 m
(B) 19.77 m
(C) 39.55 m
(D) 158.2 m

***Ans*:-** $d = d_1 + d_2 = 2\sqrt{2hR}$

$h = \frac{d^2}{8R}$

$\Rightarrow h = \frac{(45\times1000)^2}{8\times6400\times1000} \approx 39.55\ m$



***Questions*: 12:-** Amplitude of a mass-spring system, which is executing simple harmonic motion decreases with time. If mass 500g. Decay constant 20g/s then how much time is required for the amplitude of the system to drop to half of its initial value?
(In 2 = 0.693)

(A) 34.65 s
(B) 15.01 s
(C) 17.32 s
(D) 0.034 s

***Ans*:- As we know that for damping Oscillation**

$A = A_0 e^{-\frac{b}{2m}t} \Rightarrow t_{\frac{1}{2}} = \frac{\ell n(2)}{\frac{b}{2m}} = \frac{2m\ell n(2)}{b} = \frac{2\times500\times0.693}{20} = 35.65\ s$

***Questions*: 13:-** The half- life of Au^{198} is 2.7 days. The activity of 1.50 mg of Au^{198} if its atomic weight is 198 g mol^{-1} is ($N_A = 6 \times 10^{23}$/mol).

(A) 240 Ci
(B) 252 Ci
(C) 535 Ci
(D) 357 Ci

***Ans*:-** $A = \text{Activity} = \lambda N = \left(\frac{\ell n(2)}{t_{\frac{1}{2}}}\right) N = \left(\frac{0.693}{27\times24\times3600}\right) \times \left(\frac{1.5\times10^{-3}}{198} \times 6 \times 10^{23}\right)$ disintegration is

$\Rightarrow A = \left(\frac{0.693}{27\times24\times3600}\right) \times \left(\frac{1.5\times10^{-3}}{198} \times 6 \times 10^{23}\right) \times \frac{1}{3.7\times10^{10}} \approx 357\ Ci$

***Questions*: 14:-** The de – Broglie wavelength associated with an electron and a proton were calculated by accelerating them through same potential of 100V. What should be the ratio of their wavelengths?
(m_P = 1.00727u, m_e = 0.00055u)

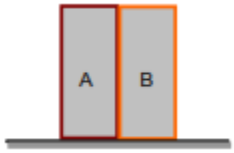
(A) 43: 1
(B) 41.4: 1
(C) 41.3: 1
(D) 1860: 1

***Ans*:-** Using de-Broglie equation:

$\lambda = \frac{h}{mv} = \frac{h}{\sqrt{2Km}} = \frac{h}{\sqrt{2(eV)m}} \Rightarrow \lambda\ \alpha \frac{1}{\sqrt{m}}$

$$\Rightarrow \frac{\lambda_e}{\lambda_p} = \sqrt{\frac{m_p}{m_e}} = \sqrt{1831} \approx 43:1$$

***Questions*: 15:-** A bimetallic strip consists of metals A and B. It is mounted rigidly as shown. The metal A has higher coefficient of expansion compared to that metal B. When bimetallic strip is placed in a cold bath, it will



(A) Neither bend nor shrink
(B) Not bend but shrink
(C) Bend towards the left
(D) Bend to wards the right

Ans:- The decrement in length is more for metal strip-A than metal strip-B, so the combined system bend towards the left.

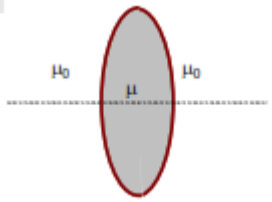
***Questions*: 16:-** The refractive index of converging lens is 1.4. What will be the focal length of this if it is placed in a medium of same refractive index? Assume the radii of curvature of the faces of lens are R_1 and R_2 respectively.

(A) 1
(B) $\frac{R_1R_2}{R_1-R_2}$
(C) Infinite
(D) Zero

Ans:- Using lens make formula, we can write

$$\frac{1}{f} = \left(\frac{1}{\mu_0} - 1\right)\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$$

$$\mu = \mu_0 \Rightarrow \frac{1}{f} = 0 \Rightarrow f \Rightarrow \text{Infinite}$$



***Questions*: 17:-** Find out the surface charge density at the intersection of point x = 3 m plane and x- axis, in the region of uniform line charge of 8 nC/m lying along the z-axis in free space.

(A) 0.424 nC m^{-2}
(B) 47.88 C/m
(C) 0.07 nC m^{-2}
(D) 4.0 nC m^{-2}

Ans:- According to Question, we can write

$$\frac{\sigma}{\varepsilon_0} = \frac{\lambda}{2\pi\varepsilon_0 r} \Rightarrow \sigma = \frac{\lambda}{2\pi r} = \frac{8\times10^{-9}}{2\times3.14\times3} = 0.424\ \text{nCm}^{-2}$$

***Questions*: 18:- Statement I:** A cyclist is moving on an un-banked road with a speed of 7 kmh^{-1} and takes a sharp circular turn along a path of radius of 2m without reducing the speed. The static friction coefficient is 0.2 The cyclist will not slip and pass the curve (g = 9.8 m/s^2).

Statement II: If the road is at an angle of 45° cyclist can cross of the curve of 2m radius with the speed of 18.5 kmh^{-1} without slipping

In the light of the above statements, choose the correct the answer from the options given below.

(A) **Statement I** is incorrect and **statement II** is correct
(B) Both statement I and statement II are true
(C) **Statement I** is correct and **statement II** is incorrect
(D) Both **statement I** and **statement II** are false

Ans:- **Statement – I:** $F_C = \frac{mv^2}{r} \le f_\ell = \mu mg \Rightarrow v \le \sqrt{\mu gR} = \sqrt{0.2 \times 10 \times 2} = 2m/s$

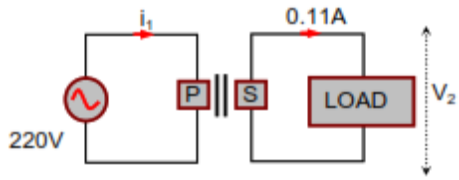
$\Rightarrow v_{cyclist} = 7 \times \frac{5}{18} = 1.94\ m/s \le 2m/s$, so **statement – I** is correct

Statement – II: $v_{min} = \sqrt{gR\left(\frac{\tan\theta - \mu}{1+\mu\tan\theta}\right)} = \sqrt{10 \times 2\left(\frac{\tan 45^o - 0.2}{1+0.2\times\tan 45^o}\right)} = \sqrt{10 \times 2\left(\frac{1-0.2}{1-0.2\times 1}\right)} = 3.65\ m/s$

$v_{max} = \sqrt{gR\left(\frac{\tan\theta + \mu}{1-\mu\tan\theta}\right)} = \sqrt{10 \times 2\left(\frac{\tan 45^o + 0.2}{1-0.2\times\tan 45^o}\right)} = \sqrt{10 \times 2\left(\frac{1+0.2}{1-0.2\times 1}\right)} = 5.48\ m/s$

$\Rightarrow v_{min} \le v_{cyclist} = 18.5 \times \frac{5}{18} = 5.139\ m/s \le v_{max}$, so statement – II is correct

***Questions*: 19:-** For the given circuit, comment on the type of transformer used.



(A) Step down transformer
(B) Auxilliary transformer
(C) Step- Up transformer
(D) Auto transformed

Ans:- Voltage across secondary source

$V_s = \frac{P}{i} = \frac{60}{0.11} \approx 545V$

Since voltage across secondary source is more than primary source

$\Rightarrow$ Step-up transformer.

***Questions*: 20:-** A resistor develops 500J of thermal energy in 20 s when a current of 1.5A is passed through it. If the current is increased from 1.5 A to 3 A, what will be the energy developed in 20 s.

(A) 2000 J
(B) 500 J
(C) 1000 J
(D) 1500 J

Ans:- Heat generated in the resistance

$H = i^2 RT$

$H_1 = 500 = (1.5)^2 R(20)$

$H_2 = H = (3)^2 R(20) \Rightarrow \frac{500}{H} = \frac{1}{4} \Rightarrow H = 2000J.$