JEE MAIN JAN 2020

PAPER WITH SOLUTION

8th January 2020 _ SHIFT - 1

PHYSICS

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1. When photon of energy 4.0 eV strikes the surface of a metal A, the ejected photo electrons have maximum kinetic energy T_A eV and de-Broglie wavelength λ_A .The maximum kinetic energy of photoelectrons liberated from another metal B by photon of energy 4.50 eV is $T_B = (T_A - 1.5)$ eV. If the de-Broglie wavelength of these photoelectrons $\lambda_B = 2\lambda_A$, then the work function of metal B is :

(1) 2 eV (2) 1.5 eV (3) 3 eV (4) 4 eV

जब 4.0 eV उर्जा के फोटॉन धातु A की सतह पर पड़ते हैं, तो इससे उत्सर्जित इलेक्ट्रॉनो की अधिकतम गतिज उर्जा T_A eV है और इनका डी–ब्रोगली तरंगदैर्ध्य λ_A है। एक दूसरी धातु B पर 4.50 eV उर्जा के फोटॉनो के पड़ने पर उत्सर्जित इलेक्ट्रॉनो की अधिकतम गतिज उर्जा $T_B = (T_A - 1.5)$ eV है। यदि इनका डी–ब्रोगली तरंगदैर्ध्य $\lambda_B = 2\lambda_A$ है, तो धातु B के कार्य फलन का मान है –

(1) 2 eV (2) 1.5 eV (3) 3 eV (4) 4 eV

Sol. **4**

Relation between De-Broglie wavelength and K.E. is

$$\lambda = \frac{h}{\sqrt{2(KE)m_e}} \Rightarrow \lambda \propto \frac{1}{\sqrt{KE}}$$

$$\frac{\lambda_A}{\lambda_B} = \frac{\sqrt{KE_B}}{\sqrt{KE_A}}$$

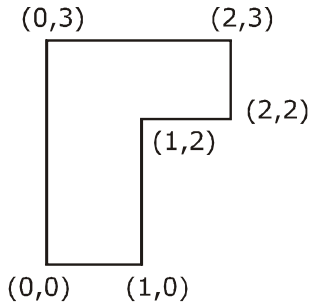
$$\Rightarrow \frac{1}{2} = \sqrt{\frac{T_A - 1.5}{T_A}}$$

$$\Rightarrow T_A = 2eV$$

$$\therefore KE_B = 2 - 1.5 = 0.5eV$$

$$\phi_B = 4.5 - 0.5 = 4eV$$

2. The coordinates of centre of mass of a uniform flag shaped lamina (thin flat plate) of mass 4 kg. (The coordinates of the same are shown in figure) are :



(1) (1.25m, 1.50m)
(2) (0.75m, 1.75m)
(3) (0.75m, 0.75m)
(4) (1m, 1.75 m)

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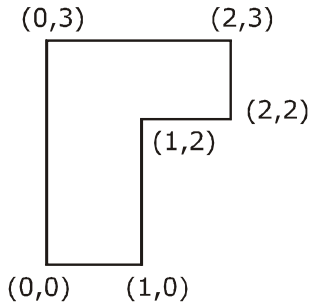
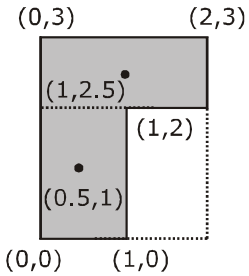
चित्र में दिखाये गये झण्डे के आकार के 4 kg द्रव्यमान वाले एक समतल एकसमान प्लेट के संहति केन्द्र के निर्देशक बिन्दु होंगे –



(1) (1.25m, 1.50m)
(2) (0.75m, 1.75m)
(3) (0.75m, 0.75m)
(4) (1m, 1.75 m)

Sol. **2**



$$\vec{r}_{cm} = \frac{1 \times \left(\frac{\hat{i}}{2} + \hat{j}\right) + 1 \times \left(\hat{i} + \frac{5\hat{j}}{2}\right)}{2}$$

$$\vec{r}_{cm} = \frac{3}{4}\hat{i} + \frac{7}{4}\hat{j}$$

3. The magnifying power of a telescope with tube length 60 cm is 5. What is the focal length of its eye piece?

(1) 10 cm (2) 20 cm (3) 40 cm (4) 30 cm

यदि एक टेलीस्कोप की ट्यूब की लम्बाई 60 cm है और इसका आवर्धन 5 हो, तो इसके नेत्रिका (eye piece) की फोकस दूरी है –

(1) 10 cm (2) 20 cm (3) 40 cm (4) 30 cm

Sol. **1**

$$m = \frac{f_0}{f_e}$$

$$5 = \frac{f_0}{f_e}$$

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$f_0 = 5f_e$
$f_0 + f_e = 60$
$6f_e = 60$
$f_e = 10$

4. The critical angle of a medium for a specific wavelength, if the medium has a relative permittivity 3 and relative permeability $\frac{4}{3}$ for this wavelength, will be :

(1) 30° (2) 15° (3) 60° (4) 45°

एक माध्यम को, एक विशेष तरंगदैर्ध्य के लिये सापेक्ष विद्युतशीलता 3 है और सापेक्ष चुम्बकशीलता $\frac{4}{3}$ है। इस तरंगदैर्ध्य के लिये माध्यम के क्रांतिक कोण का मान है –

(1) 30° (2) 15° (3) 60° (4) 45°

Sol. **1**

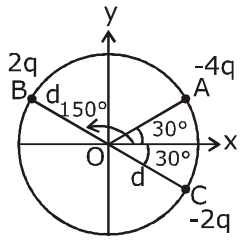
$V = \frac{1}{\sqrt{\mu\varepsilon}}$

$n = \sqrt{\mu_r\varepsilon_r} = 2$

$\sin c = \frac{1}{2}$

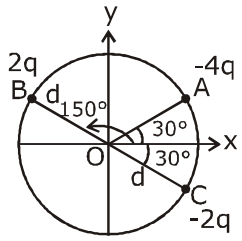
$c = 30°$

5. Three charged particles A, B and with charges –4q, 2q and –2q are present on the circumference of a circle of radius d. The charged particles A, C and centre O of the circle formed an equilateral triangle as shown in figure. Electric field at O along x-direction is :



(1) $\frac{\sqrt{3}q}{4\pi\varepsilon_0 d^2}$ (2) $\frac{3\sqrt{3}q}{4\pi\varepsilon_0 d^2}$ (3) $\frac{\sqrt{3}q}{\pi\varepsilon_0 d^2}$ (4) $\frac{2\sqrt{3}q}{\pi\varepsilon_0 d^2}$

A,B और C आवेशित कण, जिन पर आवेश क्रमशः –4q, 2q और –2q है, d त्रिज्या के एक वत्त की परिधि पर रखे हुए है। कण A, C और वत्त का केन्द्र O एक समबाहु त्रिभुज बनाते है। (चित्र देखे)। तब O पर x-दिशा में विद्युत क्षेत्र का मान है –



(1) $\frac{\sqrt{3}q}{4\pi\varepsilon_0 d^2}$ (2) $\frac{3\sqrt{3}q}{4\pi\varepsilon_0 d^2}$ (3) $\frac{\sqrt{3}q}{\pi\varepsilon_0 d^2}$ (4) $\frac{2\sqrt{3}q}{\pi\varepsilon_0 d^2}$

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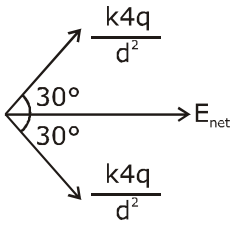
Sol. **3**



$$E_{net} = \frac{4kq}{d^2} \times 2\cos 30° = \frac{q\sqrt{3}}{\pi\varepsilon_0 d^2}$$

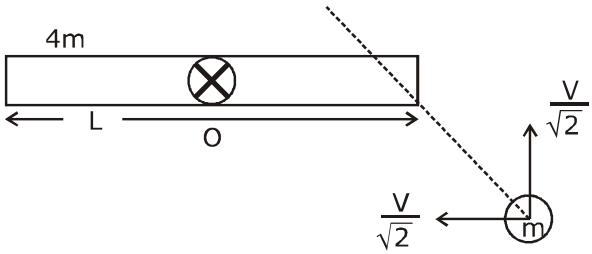
6. Consider a uniform rod of mass M = 4m and length l pivoted about its centre. A mass m moving with velocity v making angle $\theta = \frac{\pi}{4}$ to the rod's long axis collides with one end of the rod and sticks to it The angular speed of the rod-mass system just after the collision is :

(1) $\frac{3\sqrt{2}}{7}\frac{v}{L}$ (2) $\frac{4}{7}\frac{v}{L}$ (3) $\frac{3}{7\sqrt{2}}\frac{v}{L}$ (4) $\frac{3}{7}\frac{v}{L}$

द्रव्यमान M = 4m तथा l लम्बाई की एकसमान छड़ के केन्द्र पर धुराग्रस्त (pivoted) है। v गति से चलता हुआ m द्रव्यमान का एक कण, छड़ के लम्बे अक्ष से $\theta = \frac{\pi}{4}$ कोण बनाता हुआ छड़ के एक सिरे से टकराता है और इससे चिपक जाता है। छड़–कण निकाय की टक्कर के बाद कोणीय गति होगी –

(1) $\frac{3\sqrt{2}}{7}\frac{v}{L}$ (2) $\frac{4}{7}\frac{v}{L}$ (3) $\frac{3}{7\sqrt{2}}\frac{v}{L}$ (4) $\frac{3}{7}\frac{v}{L}$

Sol. **1**



$$L_{oi} = L_{of}$$

$$\frac{mV}{\sqrt{2}} \times \frac{1}{2} = \left[\frac{4mL^2}{12} + \frac{mL^2}{4}\right] \times \omega$$

$$\omega = \frac{6V}{7\sqrt{2}L} = \frac{3\sqrt{2}V}{7L}$$

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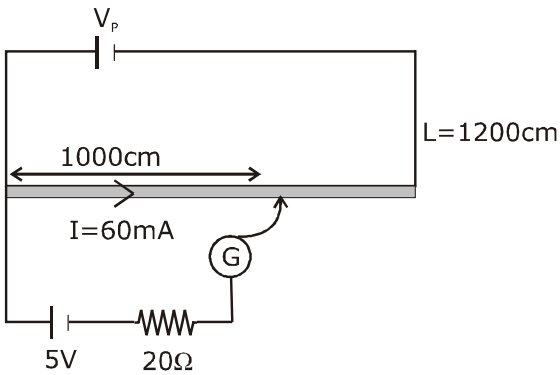
7. The length of a potentiometer wire is 1200 cm and it carries a current of 60 mA. For a cell of emf 5V and internal resistance of 20W, the null point on it is found to be at 1000 cm. The resistance of whole wire is :

(1) 100 Ω (2) 120 Ω (3) 80 Ω (4) 60 Ω

एक पोटेन्शियोमीटर के तार की लम्बाई 1200 cm है और इसमें 60 mA की विद्युत धारा प्रवाहित हो रही है। एक 5V विद्युत–वाहक बल तथा 20Ω आंतरिक प्रतिरोधक वाले सैल के लिये इस पर संतुलन बिन्दु 1000 cm पर आता है। तब पोटेन्शियोमीटर के तार का प्रतिरोध है –

(1) 100 Ω (2) 120 Ω (3) 80 Ω (4) 60 Ω

Sol. **1**

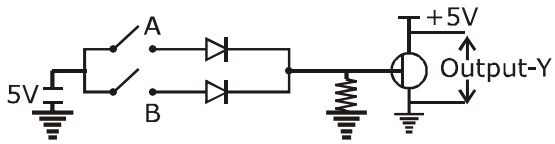


Potential gradient $= \frac{5}{1000} = \frac{V_P}{1200}$

$V_P = 6V$

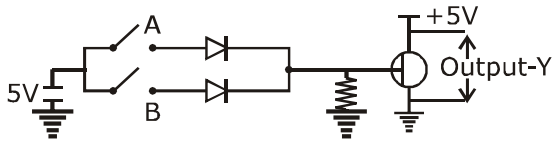
and $R_P = \frac{V_P}{I} = \frac{6}{60 \times 10^{-3}} = 100\Omega$

8. Boolean relation at the output stage-Y for the following circuit is :



(1) A·B (2) A + B (3) $\overline{A} + \overline{B}$ (4) $\overline{A} \cdot \overline{B}$

नीचे दिये गये परिपथ के निर्गत Y के लिये बूलियन संबंध होगा –



(1) A·B (2) A + B (3) $\overline{A} + \overline{B}$ (4) $\overline{A} \cdot \overline{B}$

Sol. **4**

First part of figure shown OR gate and second part of figure shown NOT gate

So, Y_P = OR + NOT = NOR gate

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

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9. Effective capacitance of parallel combination of two capacitors C_1 and C_2 is 10 μF. When these capacitors are individually connected to a voltage source of 1V, the energy stored in the capacitor C_2 is 4 times that of C_1. If these capacitors are connected in series, their effective capacitance will be :

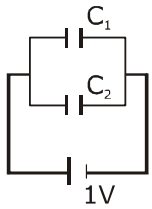
(1) 8.4 μF (2) 4.2 μF (3) 3.2 μF (4) 1.6 μF

पार्श्व संबंधन से जुड़े दो संधारित्रो C_1 तथा C_2 की प्रभावी धारिता 10 μF है। जब इन संधारित्रो को अलग–अलग 1V के स्त्रोत से जोड़ा जाता है, तो C_2 में संचित उर्जा C_1 में संचित उर्जा के 4 गुना होती है। यदि इन संधारित्रो को श्रेणीबद्ध संबंधन में जोड़ा जाये, तो इनकी प्रभावी धारिता होगी –

(1) 8.4 μF (2) 4.2 μF (3) 3.2 μF (4) 1.6 μF

Sol. **4**

Given $C_1 + C_2 = 10\mu F$ ....(i)



$$4\left(\frac{1}{2}C_1V^2\right) = \frac{1}{2}C_2V^2$$

$\Rightarrow 4C_1 = C_2$ ...(ii)

from equation (i) & (ii)

$C_1 = 2\mu F$

$C_2 = 8\mu F$

If they are in series

$$C_{eq.} = \frac{C_1C_2}{C_1 + C_2} = 1.6\mu F$$

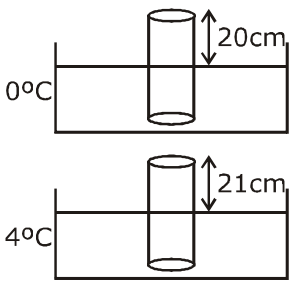
10. A leak proof cylinder of length 1m, made of a metal which has very low coefficient of expansion is floating vertically in water at 0°C such that its height above the water surface is 20 cm. When the temperature of water is increased to 4°C, the height of the cylinder above the water surface becomes 21 cm. The density of water at T = 4°C, relative to the density at T = 0°C is close to :

(1) 1.04 (2) 1.216 (3) 1.03 (4) 1.01

एक लीक प्रूफ 1m लम्बा बेलनाकार बर्तन एक ऐसी धातु का बना हुआ है, जिसका प्रसार गुणांक नगण्य है। यह सीधा होकर 0°C तापमान के पानी में तैर रहा है और इसकी लम्बाई का 20 cm भाग पानी के बाहर है। जब पानी का तापमान 4°C तक बढ़ा दिया जाता है, तो इसके बाहर रहने वाले भाग की लम्बाई 21 cm हो जाती है। तब 0°C के सापेक्ष 4°C पर पानी का घनत्व निम्न में से किसके निकट है ?

(1) 1.04 (2) 1.216 (3) 1.03 (4) 1.01

Sol. **4**



$mg = A(80)\ \rho_{0°C}g$

$mg = A(79)\ \rho_{4°C}g$

$$\frac{\rho_{4°C}}{\rho_{0°C}} = \frac{80}{79} = 1.01$$

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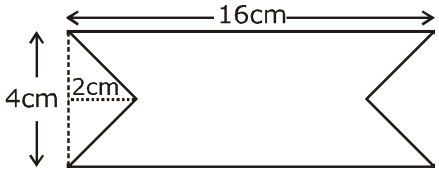
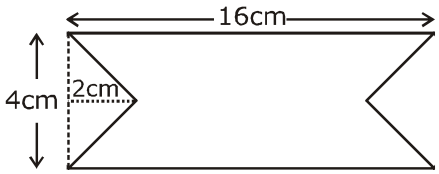
11. At time t = 0 magnetic, field of 1000 Gauses is passing perpendicularly through the area defined by the closed loop shown in the figure. If the magnetic field reduces linearly to 500 Gauss, in the next 5s, then induced EMF in the loop is :



(1) 48 μV (2) 28 μV (3) 56μV (4) 36 μV

समय t = 0 पर चित्र में दिखाये गये एक पूर्ण लूप से होकर 1000 गॉस मान का चुम्बकीय क्षेत्र इसके लम्बवत् निकलता है। यदि अगले 5s में चुम्बकीय क्षेत्र का मान रेखीय (linear) रूप से घटकर 500 गॉस हो जाता है, तो लूप में उत्प्रेरित विद्युत–वाहक बल का मान होगा –



(1) 48 μV (2) 28 μV (3) 56μV (4) 36 μV

Sol. **3**

$$\varepsilon = \left|-\frac{d\phi}{dt}\right| = \left|-\frac{AdB}{dt}\right| = .(16\times 4 - 4\times 2)\frac{(1000-500)}{5}\times 10^{-4}\times 10^{-4}$$

$$= 56\times\frac{500}{5}\times 10^{-8} = 56\times 10^{-6}\,V$$

12. The dimension of stopping potential V_0 in photoelectric effect in units of planck's constant 'h' speed of light 'c' and Gravitational constant 'G' and ampere A is :

(1) $h^{-2/3}c^{-1/3}G^{4/3}A^{-1}$ (2) $h^{2/3}c^{5/3}G^{1/3}A^{-1}$ (3) $h^2/G^{3/2}C^{1/3}A^{-1}$ (4) $h^{1/3}G^{2/3}C^{1/3}A^{-1}$

प्रकाश विद्युत प्रभाव में निरोधी विभव V_0 (stopping potential) की विमाएँ प्लांक स्थिरांक 'h', प्रकाश की गति 'c' और गुरूत्वाकर्षण स्थिरांक 'G' तथा एम्पीयर A में निम्न में से किसके व्यक्त होगा ?

(1) $h^{-2/3}c^{-1/3}G^{4/3}A^{-1}$ (2) $h^{2/3}c^{5/3}G^{1/3}A^{-1}$ (3) $h^2/G^{3/2}C^{1/3}A^{-1}$ (4) $h^{1/3}G^{2/3}C^{1/3}A^{-1}$

Sol. **Bonus**

$V = K(h)^a(I)^b(G)^C(C)^d$ (V is voltage)

we know $[h] = ML^2T^{-1}$

$[I] = A$

$[G] = M^{-1}L^3T^{-2}$

$[C] = LT^{-1}$

$[V] = M\,L^2T^{-3}A^{-1}$

$M\,L^2T^{-3}\,A^{-1} = (M\,L^2T^{-1})^a\,(A)^b\,(M^{-1}L^3T^{-2})^C\,(LT^{-1})^d$

$M\,L^2T^{-3}\,A^{-1} = M^{a-c}\,L^{2a+3c+d}\,T^{-a-2c-d}A^b$

a - c = 1 .....(1)

2a + 3c + d = 2 .....(2)

-a -2c -d = -3 .....(3)

b = -1 .....(4)

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on solving
c = -1
a = 0
d = 5, b = -1
$V = k(h)^0 (I)^{-1} (G)^{-1} (C)^5$

13. Consider a solid sphere of radius R and mass density $\rho(r) = \rho_0\left(1 - \frac{r^2}{R^2}\right)$ $0 < r \le R$. The minimum density of a liquid in which it will float is :

(1) $\frac{2\rho_0}{5}$ (2) $\frac{\rho_0}{5}$ (3) $\frac{\rho_0}{3}$ (4) $\frac{2\rho_0}{3}$

एक ठोस गोले की त्रिज्या R है और इसका घनत्व $\rho(r) = \rho_0\left(1 - \frac{r^2}{R^2}\right)$, $0 < r \le R$ है। जिस द्रव में यह प्लवन (तैर) कर सके उस द्रव का न्यूनतम घनत्व होगा –

(1) $\frac{2\rho_0}{5}$ (2) $\frac{\rho_0}{5}$ (3) $\frac{\rho_0}{3}$ (4) $\frac{2\rho_0}{3}$

Sol. **1**

$$\rho = \rho_0\left(1 - \frac{r^2}{R^2}\right) \qquad 0 < r \le R$$

mg = B

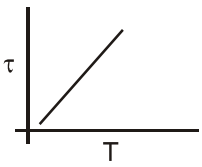
$$\int \rho\left(4\pi r^2 dr\right) = \rho_L \frac{4}{3}\pi R^3$$

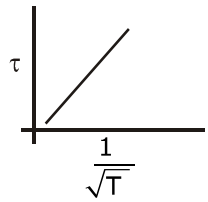
$$\int \rho\left(1 - \frac{r^2}{R^2}\right) 4\pi r^2 dr = \rho_L \frac{4}{3}\pi R^3$$

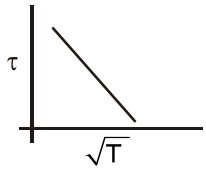
$$\int_0^R \rho_0 4\pi\left(r^2 - \frac{r^4}{R^2}\right) dr = \rho_0 4\pi\left(\frac{r^3}{3} - \frac{r^5}{5R^2}\right)_0^R = \rho_L \frac{4}{3}\pi R^3$$

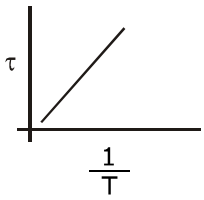
$$\frac{2}{5}\rho_0 = \rho_L$$

14. The plot that depicts the behavior of the mean free time τ (time between two successive collisions) for the molecules of an ideal gas, as a function of temperature (T,) qualitatively, is : (Graphs are schematic and not drawn to scale)

(1) 

(2) 

(3) 

(4) 

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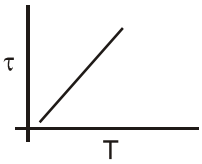
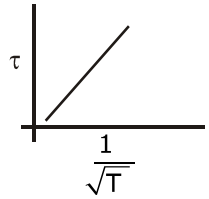
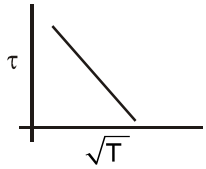
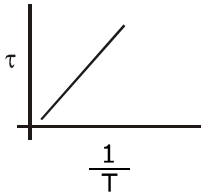
नीचे दिये गये चित्रो में से कौनसा चित्र आदर्श गैस के अणुओ का औसत मुक्त काल τ (दो उत्तरोत्तर टक्करो के बीच का समय) का तापमान (T) के साथ विचरण दिखाता है ? (रेखाचित्र सांकेतिक है)

(1) 

(2) 

(3) 

(4) 

Sol. **2**

$\tau \propto \frac{1}{\sqrt{T}}$

15. A particle of mass m is fixed to one end of a light spring having force constant k and unstreched length l. The other end is fixed. The system is given an angular speed ω about the fixed end of the spring such that it rotates in a circle in gravity free space. Then the stretch in the spring is :

(1) $\frac{ml\omega^2}{k+m\omega^2}$ (2) $\frac{ml\omega^2}{k-m\omega^2}$ (3) $\frac{ml\omega^2}{k-\omega m}$ (4) $\frac{ml\omega^2}{k+m\omega}$

m द्रव्यमान का एक कण बल स्थिरांक k एवं अतानित लम्बाई l वाली एक हल्की कमानी (spring) के एक छोर से जुड़ा हुआ हैं। कमानी का दूसरा छोर बद्ध है। इस निकाय को कोणीय गति ω देकर कमानी के बद्धछोर के चारो ओर घुमाया जाता है और यह कण गुरूत्वाकर्षण मुक्त क्षेत्र में एक वत्त में घूमने लगता है। इस स्थिति में कमानी में होने वाला खिंचाव है –

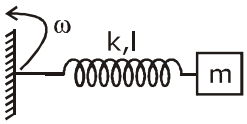
(1) $\frac{ml\omega^2}{k+m\omega^2}$ (2) $\frac{ml\omega^2}{k-m\omega^2}$ (3) $\frac{ml\omega^2}{k-\omega m}$ (4) $\frac{ml\omega^2}{k+m\omega}$

Sol. **2**

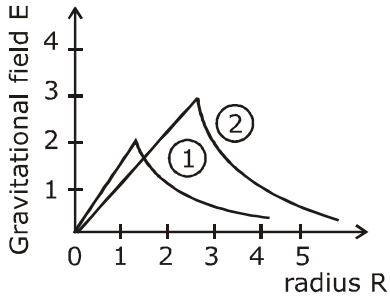
$m\omega^2(l+x) = kx$

$\left(\frac{l}{x}+1\right) = \frac{k}{m\omega^2}$

$x = \frac{lm\omega^2}{k-m\omega^2}$



16. Consider two solid spheres of a radii $R_1 = 1m$, $R_2 = 2m$ and masses M_1 amd M_2, respectively. The gravitational field due to sphere (1) and (2) are shown. The value of $\frac{M_1}{M_2}$ is :



(1) $\frac{1}{6}$ (2) $\frac{1}{3}$ (3) $\frac{1}{2}$ (4) $\frac{2}{3}$

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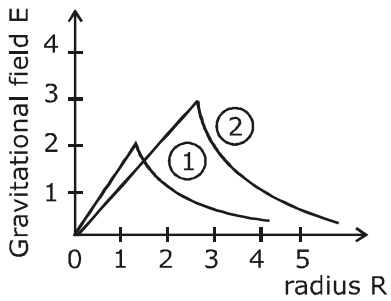
दो ठोस गोले जिनकी त्रिज्याएँ $R_1 = 1m$ और $R_2 = 2m$ है और जिनके द्रव्यमान क्रमशः M_1 तथा M_2 है, को संज्ञान में लें। गोले (1) तथा (2) द्वारा जनित गुरूत्वाकर्षण क्षेत्र चित्र में दिखाये गये हैं। तब $\frac{M_1}{M_2}$ का मान है –



(1) $\frac{1}{6}$ (2) $\frac{1}{3}$ (3) $\frac{1}{2}$ (4) $\frac{2}{3}$

Sol. **1**

$3 = \frac{Gm_2}{2^2}$

$2 = \frac{Gm_1}{1^2}$ $\therefore \frac{3}{2} = \frac{1}{4}\frac{m_2}{m_1}$

$\frac{m_1}{m_2} = \frac{1}{6}$

17. In finding the electric field using Gauss law the formula $|\vec{E}| = \frac{q_{enc}}{\varepsilon_0 |A|}$ is applicable In the formula ε_0 is permittivity of free space. A is the area of Gaussian surface and q_{ene} is charge enclosed by the Gaussian surface. This equation can be used in which of the following situation?

(1) Only when $|\vec{E}|$ = constant on the surface.
(2) Only when the Gaussian surface is an equipotential surface.
(3) For any choice of Gaussian surface.
(4) equipotential surface and $|\vec{E}|$ is constant on the surface.

गॉस के नियम का प्रयोग कर विद्युत क्षेत्र का मान $|\vec{E}| = \frac{q_{enc}}{\varepsilon_0 |A|}$ से दिया जाता है। यहाँ पर ε_0 निर्वात की विद्युतशीलता है, A गॉस सतह का क्षेत्रफल है और q_{ene} गॉस सतह द्वारा घिरा हुआ ओवश है। इस समीकरण का प्रयोग निम्न में से किस परिस्थिति में किया जा सकता है ?

(1) केवल तब ही जब $|\vec{E}|$ का मान इस सतह पर अचर हो।
(2) केवल तब ही जब गॉस सतह समविभव सतह हो।
(3) किसी भी गॉस सतह के लिये।
(4) केवल तब ही जब गॉस सतह समविभव सतह हो और $|\vec{E}|$ का मान इस सतह पर अचर हो।

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Sol. **4**

Magnitude of electric field is constant & the surface is equipotential

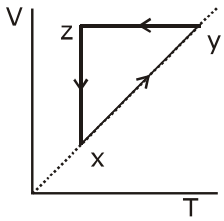
$$\oint \vec{E}.d\vec{A} = \frac{q_{enc}}{\varepsilon_0}$$

If $|\vec{E}| =$ constant and $\theta = 0°$ between $\vec{E}$ & $\overline{dA}$

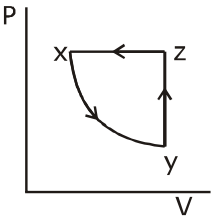
then $|E| = \frac{q_{enc}}{\varepsilon_0 |A|}$, & $\theta = 0$ possible

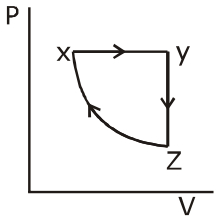
when $\vec{E} \perp \vec{r}$

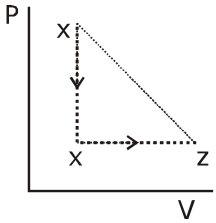
18. A thermodynamic cycle xyzx is shown on A V–T diagram.

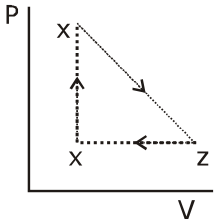


The P–V diagram that best describes this cycle is : (Diagrams are schematic and not to scale)

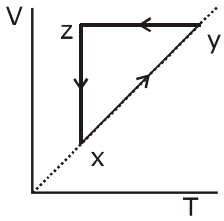
(1) 

(2) 

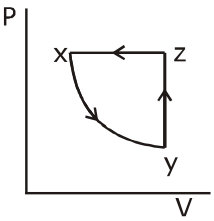
(3) 

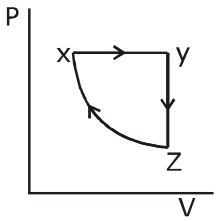
(4) 

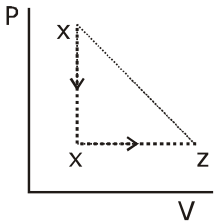
एक उष्मागतिज चक्र xyzx का (V-T) ग्राफ चित्र में दिखाया गया है।

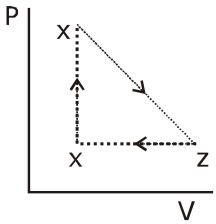


इस चक्र का सर्वोचित (P-V) ग्राफ निम्न में से कौनसा है ? (चित्र सांकेतिक है)

(1) 

(2) 

(3) 

(4) 

Sol. **2**

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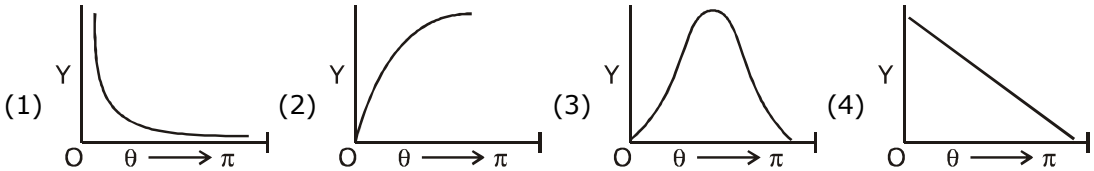
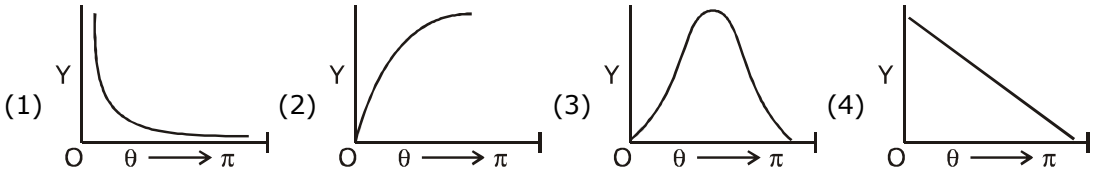
19. The graph which depicts the results of Rutherford gold foil experiment with α-particles is :
θ = Scattering angle
Y : Number of scattered a-particles detected
(Plots are schematic and not to scale)



नीचे दिये गये चित्रो में से कौनसा ग्राफ रदरफोर्ड के स्वर्ण पन्नी पर α-कणों द्वारा किये गये प्रयोग के परिणाम को दर्शाता है ? यहाँ पर :
θ = प्रकीर्णन कोण
Y : प्रकीर्णित α-कणो की संख्या
(चित्र सांकेतिक है)

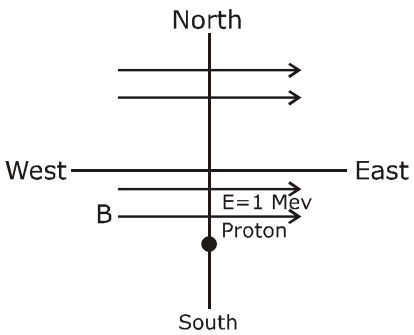


Sol. **1**

$$N \propto \frac{1}{\sin^4\left(\frac{\theta}{2}\right)}$$

20. Proton with kinetic energy of 1 MeV moves from south to north. It gets an acceleration of 10^{12} m/s^2 by an applied magnetic field (west to east). The value of magnetic field : (Rest mass of portion is 1.6×10^{-27} kg)
(1) 0.71 mT (2) 71 mT (3) 7.1 mT (4) 0.071 mT
1 MeV गतिज उर्जा वाला एक प्रोटॉन दक्षिण से उत्तर की ओर चल रहा हैं। पश्चिम से पूर्व की ओर दिशा के एक चुम्बकीय क्षेत्र से इस पर 10^{12} m/s^2 का त्वरण पैदा होता हैं। चुम्बकीय क्षेत्र का परिमाण होगा –
(प्रोटॉन का विराम द्रव्यमान = 1.6×10^{-27} kg)
(1) 0.71 mT (2) 71 mT (3) 7.1 mT (4) 0.071 mT

Sol. **1**



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$\therefore$ K.E. = $1.6\times10^{-13} = \frac{1}{2}\times1.6\times10^{-27}V^2$

$V = \sqrt{2}\times10^7$

$\therefore$ Bqv = ma

$B = \frac{1.6\times10^{-27}\times10^{12}}{1.6\times10^{-19}\times\sqrt{2}\times10^7}$

$= 0.71\times10^{-3}T$

So 0.71 mT

21. A body A, of mass m = 0.1 kg has an initial velocity of $3\hat{i}ms^{-1}$. It collides elastically with another body, B of the same mass which has an initial velocity of $5\hat{j}ms^{-1}$. After collision, A moves with a velocity $\vec{v} = 4(\hat{i}+\hat{j})$. The energy of B after collision is written as $\frac{x}{10}$ J. The value of x is _____.

द्रव्यमान m = 0.1 kg का एक पिण्ड A का आरंभिक वेग $3\hat{i}ms^{-1}$ हैं यह प्रत्यास्थ तरीके से समान द्रव्यमान के दूसरे पिण्ड B से टकराता है, जिसका आरंभिक वेग $5\hat{j}ms^{-1}$ है। टकराने के बाद, पिण्ड A, $\vec{v} = 4(\hat{i}+\hat{j})$ वेग से चल रहा है और पिण्ड B की उर्जा $\frac{x}{10}$ J है। x का मान है _____।

Sol. **1**

For elastic collision $KE_i = KE_r$

$\frac{1}{2}m\times25+\frac{1}{2}\times m\times9 = \frac{1}{2}m\times32+\frac{1}{2}mv^2$

$34 = 32 + v^2$

$KE = \frac{1}{2}\times0.1\times2 = 0.1J = \frac{1}{10}$

x = 1

22. A one meter long (both ends open) organ pipe is kept in a gas that has double the density of air at STP. Assuming the speed of sound in air at STP. Assuming the speed of sound in air at STP is 300 m/s, the frequency difference between the fundamental and second harmonic of this pipe is ..... Hz.

एक मीटर लम्बे व दोनो छोरो पर खुले हुए एक ऑर्गन पाइप को एक ऐसी गैस में रखा गया है, जिसका घनत्व वायु के मानक ताप व दाब पर घनत्व से दो गुना है। यह मानते हुए कि मानक ताप व दाब पर वायु में ध्वनि की गति 300 m/s, गैस में रखे पाइप की मूल आवत्ति और द्वितीय हारमोनिक की आवत्ति में अन्तर होगा ..... Hz.

Sol. **105.75Hz (NTA Ans = 106)**

$V = \sqrt{\frac{B}{\rho}}$

$\frac{V_{pipe}}{V_{air}} = \frac{\sqrt{\frac{B}{2\rho}}}{\sqrt{\frac{B}{\rho}}} = \frac{1}{\sqrt{2}}$

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$$V_{pipe} = \frac{V_{air}}{\sqrt{2}}$$

$$f_n = \frac{(n+1)V_{pipe}}{2\ell}$$

$$f_1 - f_0 = \frac{V_{pipe}}{2\ell} = \frac{300}{2\sqrt{2}} = 105.75 \text{ Hz (If } \sqrt{2} = 1.41)$$

$$= 106.05 \text{ Hz (If } \sqrt{2} = 1.414)$$

23. A point object in air is i front of the curved surface of a plano-convex lens. The radius of curvature of the curved surface is 30 cm. and the refractive index of the lens material is 1.5, then the focal length of the lens (in cm) is.....

एक बिन्दु के आकार की वस्तु एक समतल–उत्तल लैंस की उत्तल सतह के सामने रखा हुआ है। उत्तल सतह की त्रिज्या 30 cm है और लैंस जिससे बना है उस पदार्थ का अपवर्तनांक 1.5 है। लैन्स की फोकस दूरी का मान cm में कितना होगा .....

Sol. **60 cm**

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

$R_1 = \infty$

$R_2 = -30$ cm

$$\frac{1}{f} = (1.5 - 1)\left(\frac{1}{\infty} - \frac{1}{-30}\right)$$

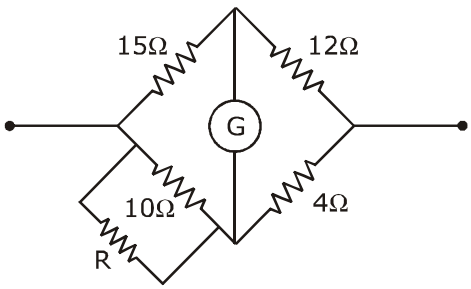
$$\frac{1}{f} = \frac{0.5}{30}$$

f = 60 cm

24. Four resistances of 15Ω, 12Ω, 4Ω and 10Ω respectively in cyclic order to form Wheatstone's network. The resistance that is to be connected in parallel with the resistance of 10Ω to balance the network is ..... Ω.

15Ω, 12Ω, 4Ω तथा 10Ω के चार प्रतिरोधको को क्रमबद्ध जोड़कर एक व्हीटस्टोन परिपथ बनाया जाता है। इस परिपथ को संतुलन में लाने के लिये 10Ω के प्रतिरोधक पर कितने Ω का एक प्रतिरोधक पार्श्व संबंधन में जोड़ा जाना चाहिये ..... Ω।

Sol. **10**



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$$\frac{10R}{10+R} \times 12 = 15 \times 4$$

on solving

R = 10Ω

25. A particle is moving along the x-axis with its coordinate with time 't' given by $x(t) = 10+8t-3t^2$. Another particle is moving along the y-axis with its coordinate as a function of time given by $y(t) = 5 - 8t^3$. At t =1 s, the speed of the second particles as measured in the frame of the first particle is given as $\sqrt{v}$. Then v (in m/s) is .....

एक कण x-अक्ष पर इस प्रकार चल रहा है कि इसका समय t के साथ x निर्देशक (coordinate) का मान $x(t) = 10+8t-3t^2$ है। एक दूसरा कण y-अक्ष पर चल रहा है और इसका y निर्देशक $y(t) = 5 - 8t^3$ द्वारा दिया जाता है। यदि t =1 s पर पहले कण के सापेक्ष दूसरे कण की गति $\sqrt{v}$ हो, तो v का मान (m/s में) है .....

Sol **580 (NTA Ans = 13, wrong ans.)**

$$X_A = -3t^2 + 8t + c$$

$$\vec{v}_A = (-6t+8)\hat{i} = 2\hat{i}$$

$$Y_B = 10 - 8t^3$$

$$\vec{V}_B = -24t^2\hat{j}$$

$$\sqrt{v} = \left|\vec{V}_B - \vec{V}_A\right| = \left|-24\hat{j} - 2\hat{i}\right|$$

$$\sqrt{v} = \sqrt{24^2 + 2^2}$$

v = 580

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