

JEE-Main-24-02-2021-Shift-2

PHYSICS

Question: Two electrons are fixed at a separation of $2d$ from each other. A proton is placed at the midpoint and displaced slightly in a direction perpendicular to line joining the two electrons. Find the frequency of oscillation of proton.

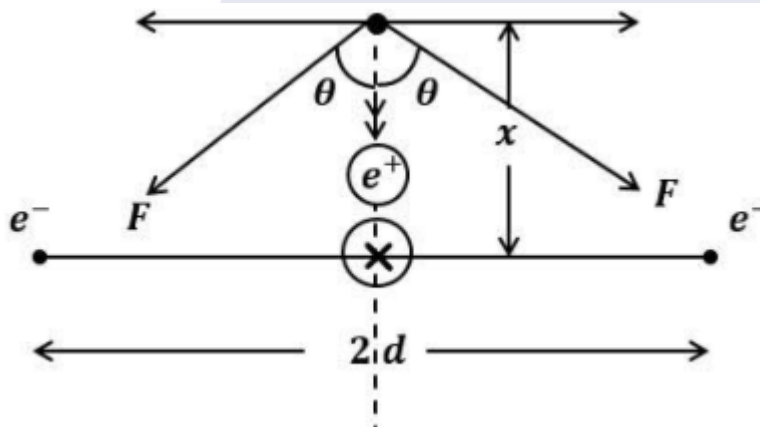
Options:

- (a) $f = \frac{1}{2\pi} \sqrt{\frac{2ke^2}{md^3}}$
(b) $f = \frac{1}{2\pi} \sqrt{\frac{ke^2}{md^3}}$
(c) $f = \frac{1}{2\pi} \sqrt{\frac{ke^2}{2md^3}}$

(d) None of these

Answer: (a)

Solution:



$$F \cos \theta \cdot 2 = m\omega^2 x$$

$$\Rightarrow \frac{k e \cdot e}{(d^2 + x^2)} \cdot \frac{2x}{\sqrt{d^2 + x^2}} = m\omega^2 x$$

$$\Rightarrow \frac{2ke^2 x}{d^3} = m\omega^2 x \quad (\text{taking } x \ll d)$$

On solving-

$$f = \frac{1}{2\pi} \sqrt{\frac{2ke^2}{md^3}}$$

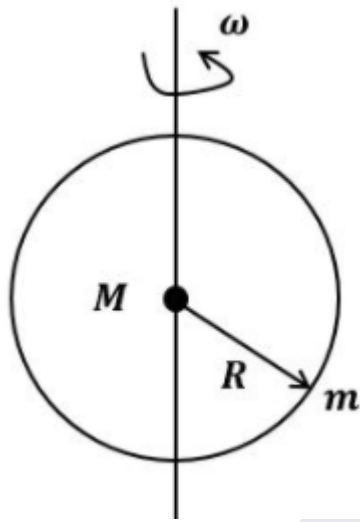
Question: The weight of a person on pole is 48 kg then the weight on equator is?
Give [R = 6400 km]

Options:

- (a) 48
- (b) 48.83
- (c) 47.84
- (d) 47

Answer: (c)

Solution:



At pole

$$\frac{GMm}{R^2} = 48 \text{ kg} \dots (i)$$

At equator

$$\frac{GMm}{R^2} - mR\omega^2 = x \dots (ii)$$

Dividing eq. (ii) by eq. (i)

$$1 - \frac{\omega^2 R^3}{GM} = \frac{x}{48}$$

On putting all the values in this eqn.

$$x = 47.83 \text{ kg.}$$

Question: Two bodies A & B have masses 1 kg & 2 kg respectively have equal momentum. Find the ratio of kinetic energy?

Options:

- (a) 1: 1
- (b) 2: 1
- (c) 1: 4
- (d) 1: 2

Answer: (b)

Solution:

$$K = \frac{P^2}{2m}$$

$$\frac{K_A}{K_B} = \frac{m_B}{m_A} \quad [\text{As momentum is same for both}]$$

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

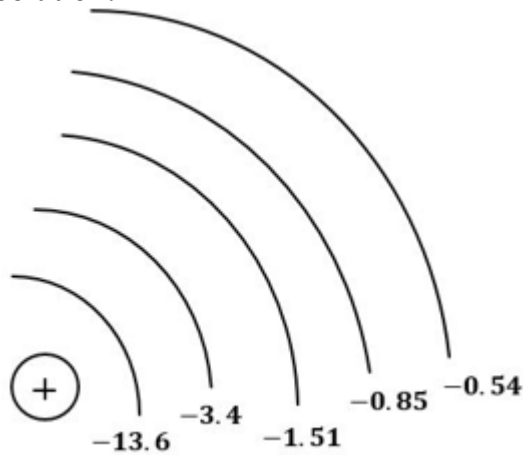
Question: Which transition in hydrogen spectrum has the maxima frequency?

Options:

- (a) $3 \rightarrow 2$
- (b) $5 \rightarrow 4$
- (c) $9 \rightarrow 5$
- (d) $2 \rightarrow 1$

Answer: (d)

Solution:



As n increases, difference between n^{th} and $(n+1)^{\text{th}}$ orbit energy decreases.

So as per given options $2 \rightarrow 1$ transition will have maximum energy & hence maximum frequency.

Question: A rod of mass M , length L is bent in the form of hexagon. Then MOI about axis passing through geometric centre & perpendicular to plane of body will be ?

Options:

- (a) $6ML^2$
- (b) $\frac{ML^2}{6}$
- (c) $\frac{ML^2}{2}$
- (d) $\frac{5ML^2}{216}$

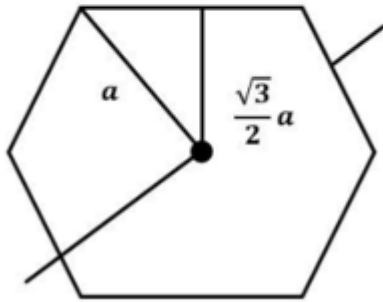
Answer: (d)

Solution:

M, L



m, a



$$m = \frac{M}{6} \text{ and } a = \frac{L}{6}$$

$$I = 6 \left[\frac{ma^2}{16} + m \left[\frac{\sqrt{3}a}{2} \right]^2 \right]$$

$$= 6ma^2 \left[\frac{1}{12} + \frac{3}{4} \right]$$

$$= 6 \times \frac{M}{6} \times \frac{L^2}{36} \times \frac{5}{6}$$

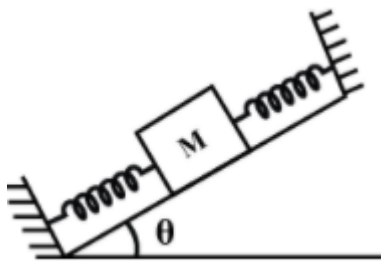
$$= \frac{5ML^2}{216}$$



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Question: Find the time period of SHM of the block of mass M .



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Options:

(a) $T = 2\pi \sqrt{\frac{M}{2K}}$

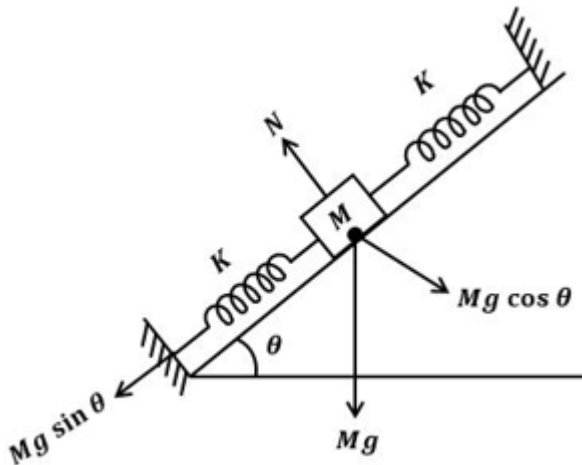
(b) $T = 2\pi \sqrt{\frac{M}{K}}$

(c) $T = 2\pi \sqrt{\frac{2M}{K}}$

(d) $T = 2\pi \sqrt{\frac{M}{4K}}$

Answer: (a)

Solution:



Constant force doesn't change ω of the system. (Constant force means force that has constant magnitude and direction. In the direction of oscillation these forces have constant contribution.)

So, due to parallel combination of springs-

$$K_{eq} = 2K$$

Therefore, $\omega = \sqrt{\frac{K_{eq}}{M}} \Rightarrow T = 2\pi \sqrt{\frac{M}{2K}}$

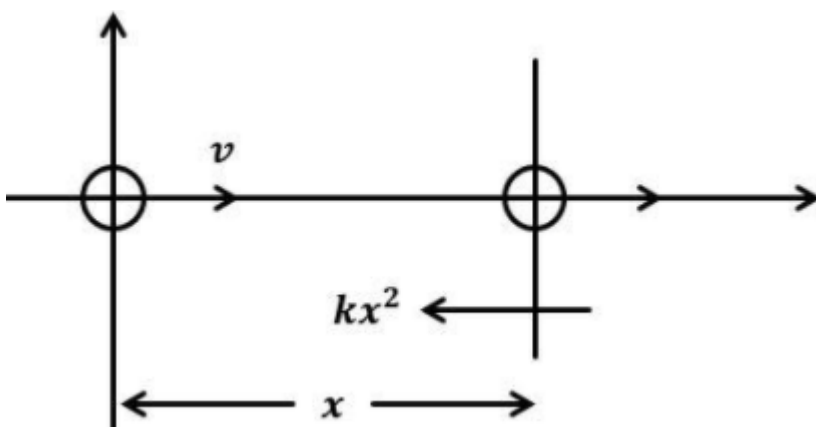
Question: A particle is projected on x axis with velocity v . A force is acting on it in opposite direction, which is proportional to the square of its position. At what distance from origin the particle will stop. [mass is m and constant of proportionality $\rightarrow k$]

Options:

- (a) $\sqrt[3]{\frac{mv_0^2}{k}}$
- (b) $\sqrt[3]{\frac{3mv_0^2}{k}}$
- (c) $\sqrt[3]{\frac{3}{2} \frac{mv_0^2}{k}}$
- (d) $\sqrt[3]{\frac{mv_0^2}{2k}}$

Answer: (c)

Solution:



Let particle will stop at l distance

$$\frac{-kx}{m} = \frac{v dv}{dx}$$

$$\int_0^l -\frac{kx^2}{m} dx = \int_v^0 v dv$$

$$\frac{-k}{m} \frac{l^3}{3} = \frac{-v^2}{2}$$

$$\Rightarrow l = \sqrt[3]{\frac{3mv_0^2}{2k}}$$

Question: Two cars are approaching each other each moving with a speed v . Find the beat frequency as heard by driver of one car both are emitting sound of frequency f_0 .

Options:

(a) Beat frequency = $\frac{2vf_0}{C-v}$

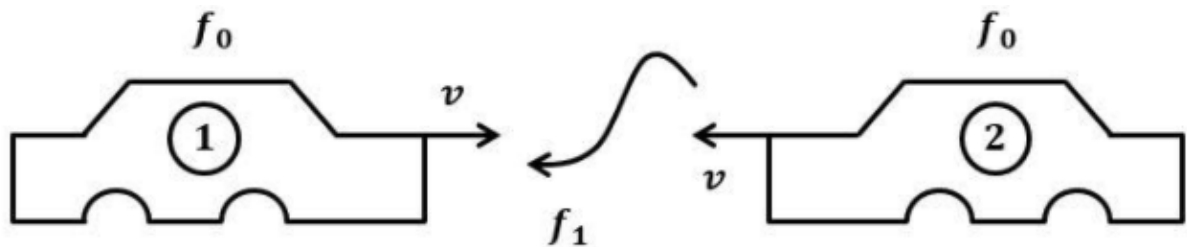
(b) Beat frequency = $\frac{2vf_0}{C+v}$

(c) Beat frequency = $\frac{vf_0}{C-v}$

(d) None of these

Answer: (a)

Solution:



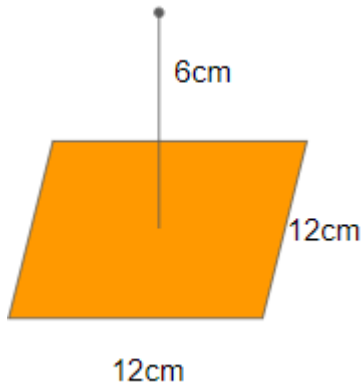
$$f_B = f_1 - f_2$$

[Where f_B is beat frequency]

$$= f_0 \left(\frac{C+v}{C-v} \right) - f_0$$

$$\Rightarrow f_B = \frac{2vf_0}{C-v}$$

Question: Find the flux of point charge 'q' through the square surface ABCD as shown.



Options:

(a) $\frac{q}{6\epsilon_0}$

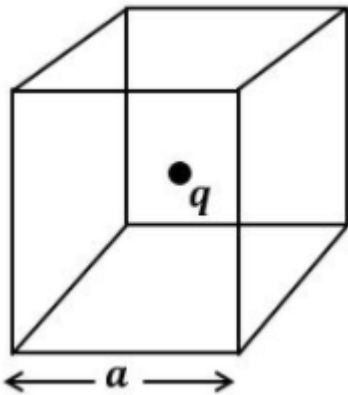
(b) $\frac{q}{\epsilon_0}$

(c) $\frac{q}{4\epsilon_0}$

(d) $\frac{q}{2\epsilon_0}$

Answer: (a)

Solution:



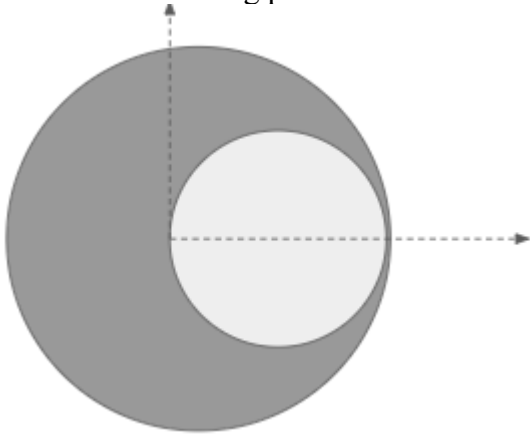
Lets assume a cube of side a and charge is at its centre.

So, from whole cube flux coming out = $\frac{q}{\epsilon_0}$

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So, flux coming out from one surface = $\frac{q}{6\epsilon_0}$

Question: If a solid cavity whose diameter is removed from a solid sphere of radius R, then the com of remaining part is at?



Options:

(a) $x = \frac{-R}{3}$

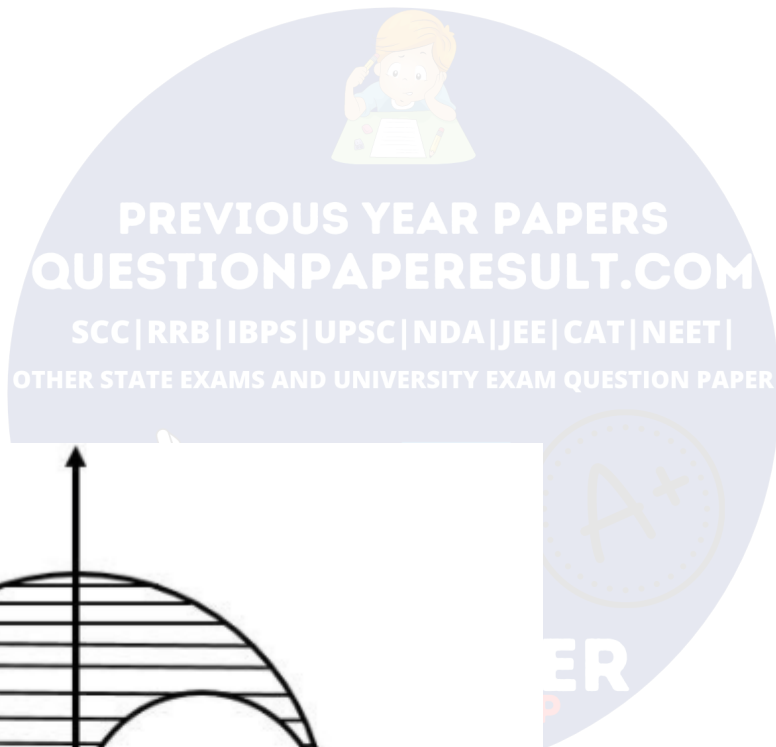
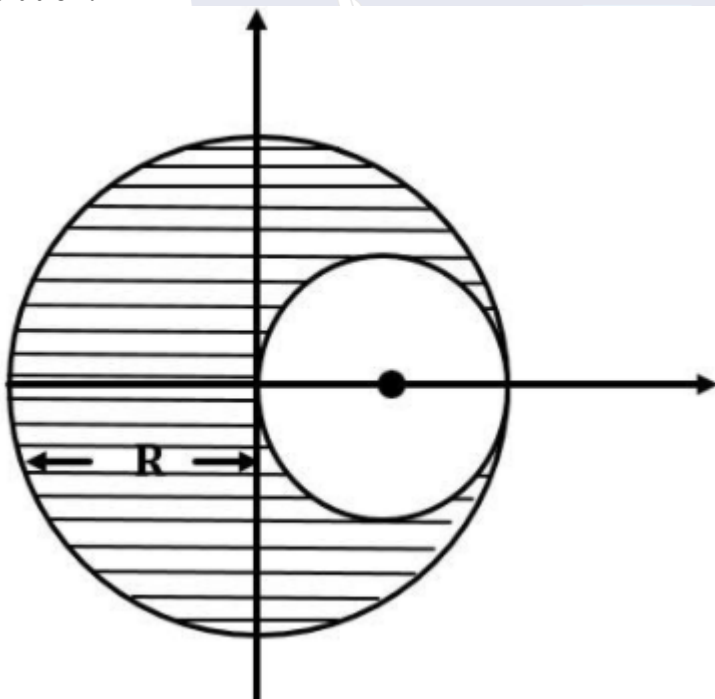
(b) $x = \frac{-R}{7}$

(c) $x = \frac{-R}{6}$

(d) $x = \frac{-R}{14}$

Answer: (c)

Solution:



$$M = \sigma\pi R^2, m = -\sigma\pi\left(\frac{R}{2}\right)^2$$

$$x_{cm} = \frac{M(0) + m\left(\frac{R}{2}\right)}{M + m} = \frac{\left(\frac{m}{M}\right)\left(\frac{R}{2}\right)}{1 + \frac{m}{M}}$$

$$\Rightarrow x_{cm} = \frac{-R}{6}$$

Question: In a YDSE experiment, if Red light is replaced by violet light then the fringe width will be

Options:

- (a) decrease
- (b) increase
- (c) may increase or decrease
- (d) None of these

Answer: (a)

Solution:

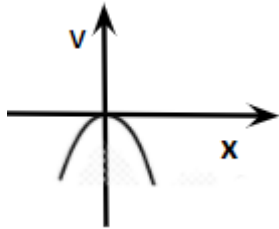
$$\beta = \frac{\lambda D}{d}$$

As λ decreases for violet light, the fringe width will also decrease.

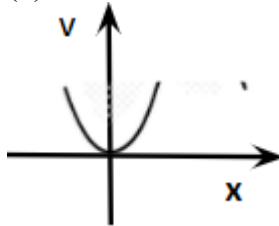
Question: The graph of V versus x in an SHM is (v : velocity, x : displacement)

Options:

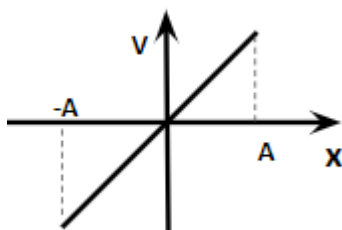
(a)







(b)

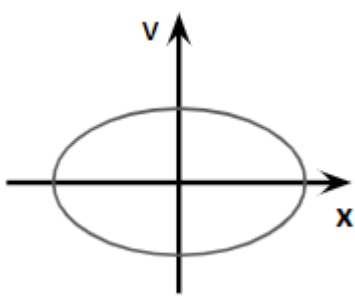


(c)



(d)

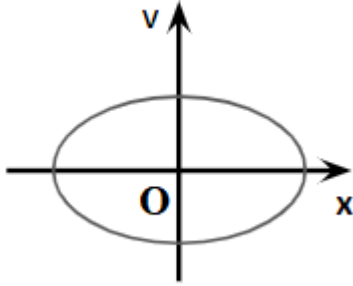

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Answer: (d)

Solution:

A simple harmonic motion is an example of periodic motion. In simple harmonic motion, a particle is accelerated towards a fixed point (in this case, O) and the acceleration of the particle will be proportional to the magnitude of the displacement of the particle.



Question: If the de Broglie wavelengths of an alpha particle and a proton are the same, then the ratio of their velocities is:

Options:

- (a) $\frac{1}{4}$
- (b) $\frac{4}{1}$
- (c) $\frac{1}{2}$
- (d) 1





Answer: (a)

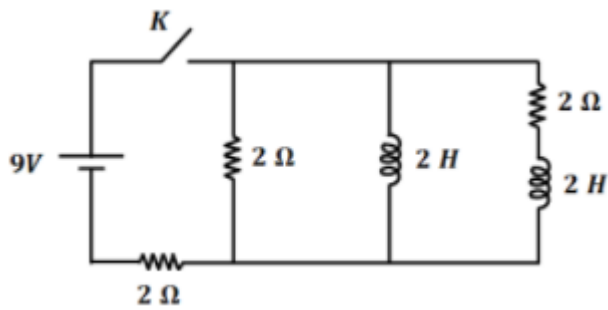
Solution:

$$\frac{h}{m_\alpha v_\alpha} = \frac{h}{m_p v_p}$$

$$\Rightarrow \frac{v_\alpha}{v_p} = \frac{m_p}{m_\alpha} = \frac{1}{4}$$

Question: Find the current through the battery just after the key is closed.


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Options:

(a) $\frac{9}{4} A$

(b) $\frac{9}{2} A$

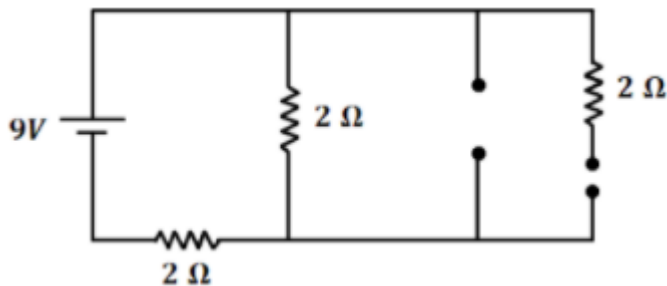
(c) $\frac{9}{1} A$

(d) None of these

Answer: (a)

Solution:

Just after the key is closed, circuit will be



So current in the circuit

$$I = \frac{9}{R_{eq}} = \frac{9}{4} \text{ Amp}$$

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CHEMISTRY

Question: S in Buna-S stands for?

Options:

- (a) Styrene
- (b) Strength
- (c) Stoichiometry
- (d) Secondary

Answer: (a)

Solution: Buna-S \Rightarrow Styrene butadiene

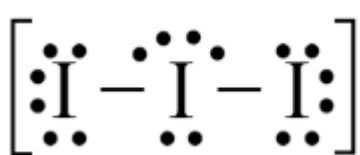
Question: Bond angle and shape of I_3^- ion is?

Options:

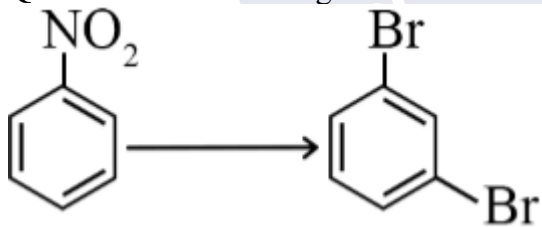
- (a) 180° and sp^3d
- (b) 180° and sp^3d^2
- (c) 90° and sp^3d
- (d) 90° and sp^3d^2

Answer: (a)

Solution:



Question: The following conversion can take place by:

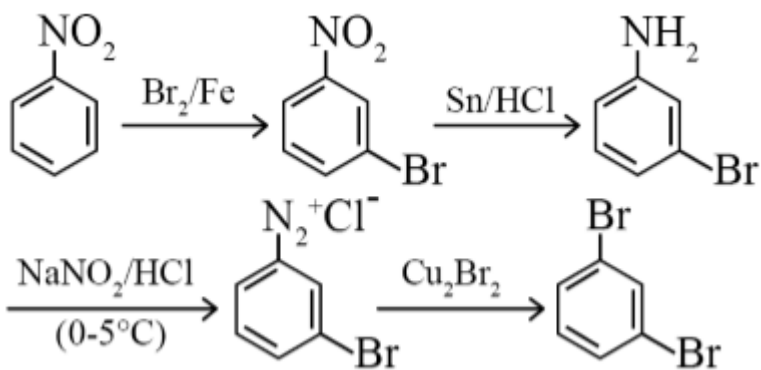


Options:

- (a) (i) Br_2/Fe (ii) Sn/HCl
- (b) (i) Br_2/Fe (ii) Sn/HCl (iii) $NaNO_2/HCl$ (iv) Cu_2Br_2
- (c) (i) Cu_2Br_2 (ii) Sn/HCl (iii) Br_2/Fe
- (d) None of these

Answer: (b)

Solution:



Question: According to Bohr's model which of the following transition will be having maximum frequency?

Options:

- (a) 3 to 2
- (b) 5 to 4
- (c) 4 to 3
- (d) 2 to 1

Answer: (d)

Solution: 2 to 1 (Lyman series)

Lyman series falls in UV region. Therefore higher energy than other radiations.

Question: PbI_2 given as = 0.1 M ; $K_{sp} = 8 \times 10^{-9}$

Find solubility of Pb^{2+}

Options:

- (a) 1.4×10^{-3}
- (b) 2×10^{-4}
- (c) 1.26×10^{-3}
- (d) 1.8×10^{-2}

Answer: (c)

Solution:

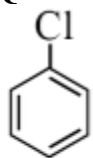
$$K_{sp} = 4s^3$$

$$8 \times 10^{-9} = 4s^3$$

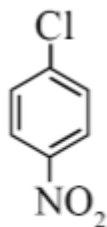
$$s^3 = 2 \times 10^{-9}$$

$$s = 1.26 \times 10^{-3}$$

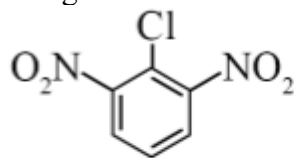
Question: Increasing strength towards nucleophilic attack ?



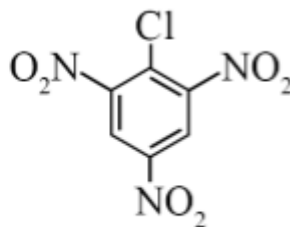
(I)



(II)



(III)



(IV)

Options:

- (a) (I) < (II) < (III) < (IV)
- (b) (IV) < (III) < (II) < (I)

(c) (IV) < (II) < (III) < (I)

(d) (I) < (III) < (II) < (IV)

Answer: (a)

Solution: Electron withdrawing groups increases the rate of nucleophilic substitution reaction, due to increase of electrophilic character of carbon involved in C – X bond.

Question:

Statement 1: Hydrogen is most abundant in universe but not so in Earth's troposphere.

Statement 2: Hydrogen is the lightest element.

Options:

(a) Statement 1 is correct and Statement 2 is incorrect.

(b) Statement 1 is incorrect and Statement 2 is correct.

(c) Statement 1 is correct and Statement 2 is correct explanation for statement 1.

(d) Statement 1 is correct and Statement 2 is incorrect explanation for statement 1.

Answer: (c)

Solution: Due to light weight of hydrogen, it is not abundant in earth's troposphere.

Question: Which of the following salts help in blood clotting?

Options:

(a) FeCl₃

(b) Mg(HCO₃)₂

(c) NaHCO₃

(d) FeSO₄

Answer: (a)

Solution: Blood being a colloidal solution its coagulation can be understood by Hardy-Schulz's law which states that higher is the charge on cation, higher will be its efficiency to coagulate the colloidal solution.

In the present case, ferric chloride has Fe³⁺. Hence, ferric chloride is more effective in enhancing the coagulation rate of blood and stop the bleeding from the cut.

Question: Match the following:

A	B
(p) Al	(i) Siderite
(q) Zn	(ii) Malachite
(r) Fe	(iii) Calamine
(s) Cu	(iv) Bauxite

Options:

(a) p → (iv); q → (iii), r → (i), s → (ii)

(b) p → (i); q → (ii), r → (iv), s → (iii)

(c) p → (iv); q → (iii), r → (ii), s → (i)

(d) p → (iii); q → (iv), r → (i), s → (ii)

Answer: (a)

Solution:

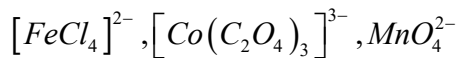
Siderite - FeCO₃

Malachite – CuCO₃ Cu(OH)₂

Calamine – ZnCO₃

Bauxite – Al₂O₃

Question: What will be the magnetic moments (spin only values) of the following complexes?

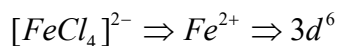


Options:

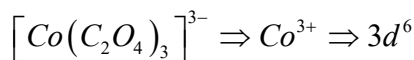
- (a) $\sqrt{3}, 0, 0$
 (b) $\sqrt{24}, 0, \sqrt{3}$
 (c) $\sqrt{24}, \sqrt{24}, 0$
 (d) $\sqrt{3}, 0, \sqrt{24}$

Answer: (b)

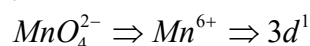
Solution:



$$\mu = \sqrt{24} \text{ B.M}$$



$$\mu = 0 \text{ B.M}$$



$$\mu = \sqrt{3} \text{ B.M}$$

Question: Compare the wavelength in flame test for LiCl, NaCl, KCl, RbCl, CsCl

Options:

- (a) NaCl < CsCl < LiCl < RbCl < KCl
 (b) CsCl < NaCl < LiCl < KCl < RbCl
 (c) RbCl < KCl < LiCl < CsCl < NaCl
 (d) CsCl < NaCl < KCl < LiCl < RbCl

Answer: (b)

Solution:

Compound	Wavelength (λ) (in nm)
LiCl	670.8
NaCl	584.2
KCl	766.5
RbCl	780
CsCl	455

Question: Choose incorrect statement:

Options:

- (a) RuO₄ is oxidizing agent
 (b) OsO₄ is reducing agent
 (c) Cr₂O₃ is amphoteric
 (d) Red colour of ruby is due to Co³⁺

Answer: (b)

Solution: OsO₄ \Rightarrow Maximum oxidation state (+8) Hence, it can get reduce and oxidise other species i.e. it is a oxidizing agent.

Question: Which of the following has highest M.P.?

Options:

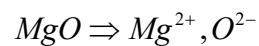
- (a) MgO
 (b) LiF

(c) NaCl

(d) LiCl

Answer: (a)

Solution:



Due to higher charge, ionic character will be high and hence, melting point also.

Question: Arrange the following in the increasing order of their density: Zn, Fe, Cr, Co

Options:

(a) Zn < Cr < Co < Fe

(b) Fe < Co < Cr < Zn

(c) Fe < Cr < Co < Zn

(d) Zn < Cr < Fe < Co

Answer: (d)

Solution:

$$\text{Density} = \frac{\text{mass}}{\text{volume}}$$

firstly, metallic radius of transition elements (first transition series) decreases from Sc to Ni then increases from Ni to Zn.

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MATHEMATICS

Question: Given, $f(0) = 1, f(2) = e^2, f'(x) = f'(2-x)$, then the value of $\int_0^2 f(x) dx$ is

Options:

- (a) $1 - e^2$
- (b) $1 + e^2$
- (c) $3e$
- (d) e^2

Answer: (b)

Solution:

$$f'(x) = f'(2-x)$$

Integrate w.r.t. x

$$f(x) = -f(2-x) + C$$

Put $x = 0$

$$f(0) = -f(2) + C$$

$$1 = -e^2 + C$$

$$C = 1 + e^2$$

$$\therefore f(x) = -f(2-x) + 1 + e^2$$

$$\Rightarrow f(x) + f(2-x) = 1 + e^2 \quad \dots(i)$$

$$\text{Let, } I = \int_0^2 f(x) dx \quad \dots(ii)$$

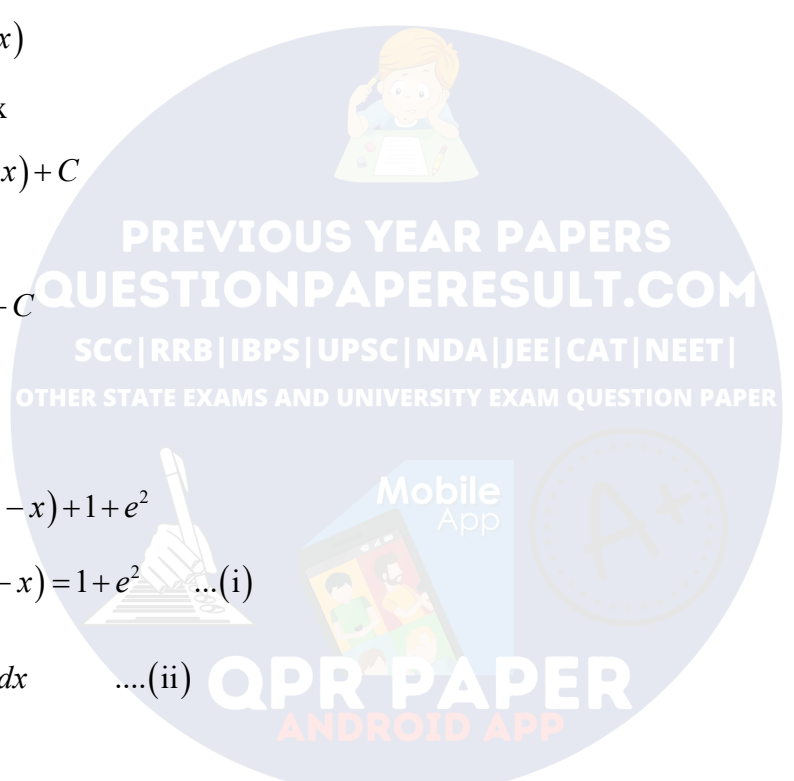
$$I = \int_0^2 f(2-x) dx \quad \dots(iii)$$

$$(ii) + (iii)$$

$$2I = \int_0^2 [f(x) + f(2-x)] dx$$

$$2I = \int_0^2 (1 + e^2) dx \quad (\text{from (i)})$$

$$2I = 2(1 + e^2)$$



$$\Rightarrow I = 1 + e^2$$

Question: The area of region defined by $5x^2 \leq y \leq 2x^2 + 9$

Options:

(a) $6\sqrt{3}$

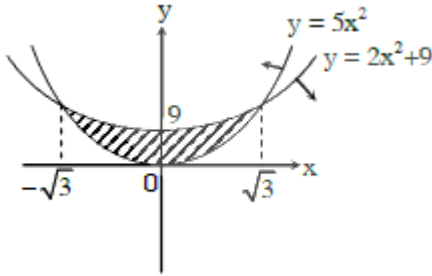
(b) $12\sqrt{3}$

(c) $18\sqrt{3}$

(d) $9\sqrt{3}$

Answer: (b)

Solution:



Intersection points

$$5x^2 = 2x^2 + 9$$

$$3x^2 = 9$$

$$x^2 = 3$$

$$x = \pm\sqrt{3}$$

$$\text{Area} = \int_{-\sqrt{3}}^{\sqrt{3}} (2x^2 + 9 - 5x^2) dx$$

$$= 2 \int_0^{\sqrt{3}} (9 - 3x^2) dx$$

$$= 2 [9x - x^3]_0^{\sqrt{3}}$$

$$= 2(9\sqrt{3} - 3\sqrt{3})$$

$$= 12\sqrt{3}$$

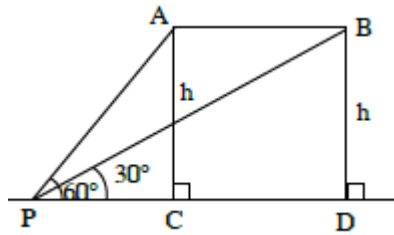
Question: A plane is flying horizontally with speed 120 m/s . Its angle of elevation from a point on ground is 60° . After 20s angle of elevation is 30° . Find height of plane

Options:

- (a) $1200\sqrt{3}$
- (b) $2400\sqrt{3}$
- (c) $600\sqrt{3}$
- (d) $1500\sqrt{3}$

Answer: (a)

Solution:



$$AB = h \cot 60^\circ = \frac{h}{\sqrt{3}}$$

$$AC = h \cot 30^\circ = \sqrt{3}h$$

$$BC = AC - AB = \sqrt{3}h - \frac{h}{\sqrt{3}} = 120 \times 20$$

$$\Rightarrow \frac{2h}{\sqrt{3}} = 120 \times 20$$

$$\Rightarrow h = 1200\sqrt{3}m$$

Question: Negation of the statement $\sim p \vee (p \wedge q)$ is

Options:

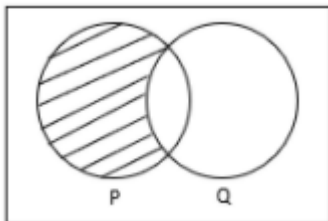
- (a) $p \wedge \sim q$
- (b) $p \vee \sim q$
- (c) $\sim p \wedge q$
- (d) $\sim p \vee \sim q$

Answer: (b)

Solution:

$$\sim(\sim p \vee (p \wedge q)) = p \wedge \sim(p \wedge q)$$

= only p



Question: Vertices of Δ are (a, c) , $(2, b)$ and (a, b) , a, b, c are in A.P. centroid is $\left(\frac{10}{3}, \frac{7}{3}\right)$. If

α, β are roots of $ax^2 + bx + 1 = 0$ then $\alpha^2 + \beta^2 - \alpha\beta =$

Options:

(a) $-\frac{71}{256}$

(b) $\frac{71}{256}$

(c) $\frac{69}{256}$

(d) $-\frac{69}{256}$

Answer: (a)

Solution:

a, b, c are in A.P. $\Rightarrow 2b = a + c \quad \dots(i)$

Centroid $= \left(\frac{2a+2}{3}, \frac{2b+c}{3} \right) = \left(\frac{10}{3}, \frac{7}{3} \right)$

$\Rightarrow \frac{2a+2}{3} = \frac{10}{3} \Rightarrow a = 4$

and $\frac{2b+c}{3} = \frac{7}{3} \Rightarrow a+c+c = 7$ (from (i))

$\Rightarrow 2c+4 = 7 \Rightarrow c = \frac{3}{2}$

Put in (i)

$2b = 4 + \frac{3}{2} = \frac{11}{2}$

$b = \frac{11}{4}$

α, β are root of $ax^2 + bx + 1 = 0$

$\Rightarrow \alpha + \beta = \frac{-b}{a} = \frac{-11}{16}, \alpha\beta = \frac{1}{a} = \frac{1}{4}$

So, $\alpha^2 + \beta^2 - \alpha\beta = (\alpha + \beta)^2 - 3\alpha\beta$

$= \left(\frac{-11}{16} \right)^2 - \frac{3}{4}$

$= \frac{121-192}{256} = \frac{-71}{256}$

Question: If $\begin{vmatrix} f(x) & f'(x) \\ f'(x) & f''(x) \end{vmatrix} = 0, f(x) = 1, f'(0) = 2, f''(x) \neq 0$ then $f(1)$ lies in

Options:

(a) (0, 3)

(b) (6, 9)

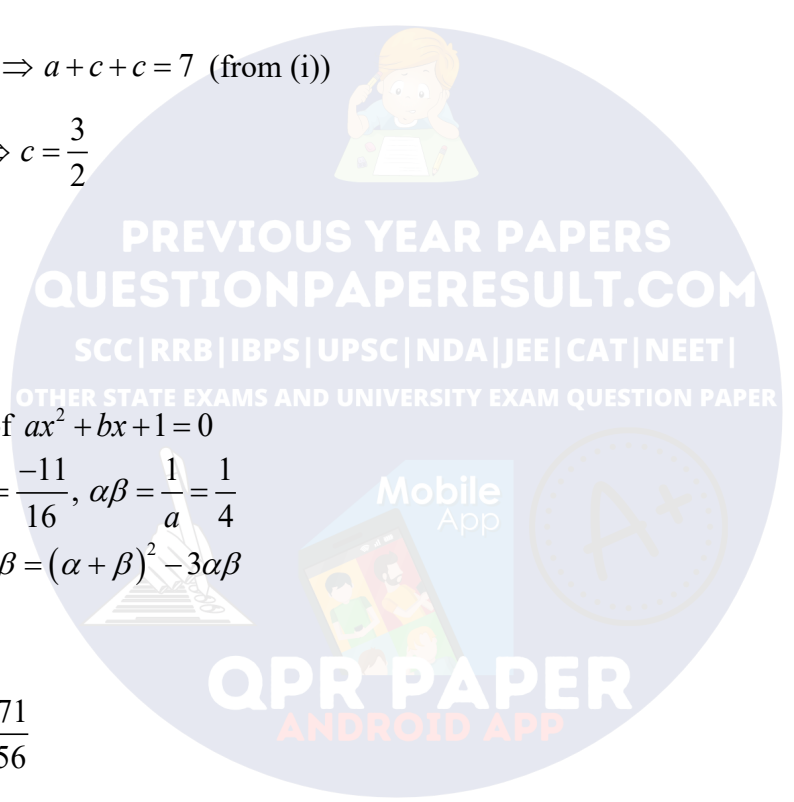
(c) [9, 12]

(d) [5, 7]

Answer: (b)

Solution:

$f(x)f''(x) - [f'(x)]^2 = 0$



$$\Rightarrow \frac{f''(x)}{f'(x)} = \frac{f'(x)}{f(x)}$$

$$\Rightarrow \int \frac{f''(x)}{f'(x)} dx = \int \frac{f'(x)}{f(x)} dx$$

$$\Rightarrow \log f'(x) = \log f(x) + \log c$$

$$\Rightarrow f'(x) = c f(x)$$

Put $x = 0$

$$f'(0) = c f(0)$$

$$\Rightarrow 2 = c$$

$$\Rightarrow f'(x) = 2f(x)$$

$$\Rightarrow \int \frac{f'(x)}{f(x)} dx = \int 2 dx$$

$$\log f(x) = 2x + D$$

$$f(x) = e^D e^{2x}$$

$$f(x) = K e^{2x} \quad (\text{Put } e^D = k)$$

Put $x = 0$

$$f(0) = K$$

$$\Rightarrow K = 1$$

$$\Rightarrow f(x) = e^{2x}$$

$$\Rightarrow f(1) = e^2$$

which lies in (6, 9)

Question: The value of $\tan\left(\frac{1}{4} \sin^{-1} \frac{\sqrt{63}}{8}\right)$ is

Options:

(a) $\frac{1}{\sqrt{7}}$

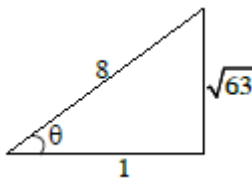
(b) $\frac{1}{\sqrt{5}}$

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

(d) none of these

Answer: (a)

Solution:



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$$\text{Let } \sin^{-1} \frac{\sqrt{63}}{8} = \theta$$

$$\Rightarrow \sin \theta = \frac{\sqrt{63}}{8}$$

$$\Rightarrow \cos \theta = \frac{1}{8}$$

$$\Rightarrow \cos \frac{\theta}{2} = \sqrt{\frac{1 + \cos \theta}{2}} = \sqrt{\frac{1 + \frac{1}{8}}{2}} = \sqrt{\frac{9}{16}} = \frac{3}{4}$$

$$\text{So, } \tan\left(\frac{1}{4} \sin^{-1} \frac{\sqrt{63}}{8}\right) = \tan\left(\frac{\theta}{4}\right)$$

$$= \sqrt{\frac{1 - \cos\left(\frac{\theta}{2}\right)}{1 + \cos\left(\frac{\theta}{2}\right)}} = \sqrt{\frac{1 - \frac{3}{4}}{1 + \frac{3}{4}}} = \frac{1}{\sqrt{7}}$$

Question: The number of natural numbers less than 7,000 which can be formed by using the digits 0, 1, 3, 7, 9 (repetition of digits allowed) is equal to

Options:

- (a) 250
- (b) 374
- (c) 372
- (d) 375

Answer: (b)

Solution:

7 and 9 cannot occur at first place

Hence, required number of natural numbers less than 7000

$$= 3 \times 5 \times 5 \times 5 - 1 = 375 - 1 = 374$$

(we have subtracted 1 for the case 0000 case)

Question: Find the value of ${}^{n+1}C_2 + 2({}^2C_2 + {}^3C_2 + \dots + {}^nC_2) = ?$

Options:

- (a) $\frac{n(n+1)(2n-1)}{6}$
- (b) $\frac{n(n+1)(2n+1)}{6}$
- (c) $\frac{(n-1)n(n+1)}{6}$

$$(d) \frac{n(n+1)}{2}$$

Answer: (b)

Solution:

$$\begin{aligned} S &= {}^2C_2 + {}^3C_2 + \dots + {}^nC_2 = {}^{n+1}C_3 \\ \therefore {}^{n+1}C_2 + {}^{n+1}C_3 + {}^{n+1}C_3 &= {}^{n+2}C_3 + {}^{n+1}C_3 \\ &= \frac{(n+1)!}{3!(n-1)!} + \frac{(n+1)!}{3!(n-2)!} \\ &= \frac{(n+2)(n+1)n}{6} + \frac{(n+1)n(n-1)}{6} = \frac{n(n+1)}{6}(2n+1) \end{aligned}$$

Question: If A and B are subsets of $X = \{1, 2, 3, 4, 5\}$ then find the probability such that $n(A \cap B) = 2$

Options:

(a) $\frac{65}{2^7}$

(b) $\frac{65}{2^9}$

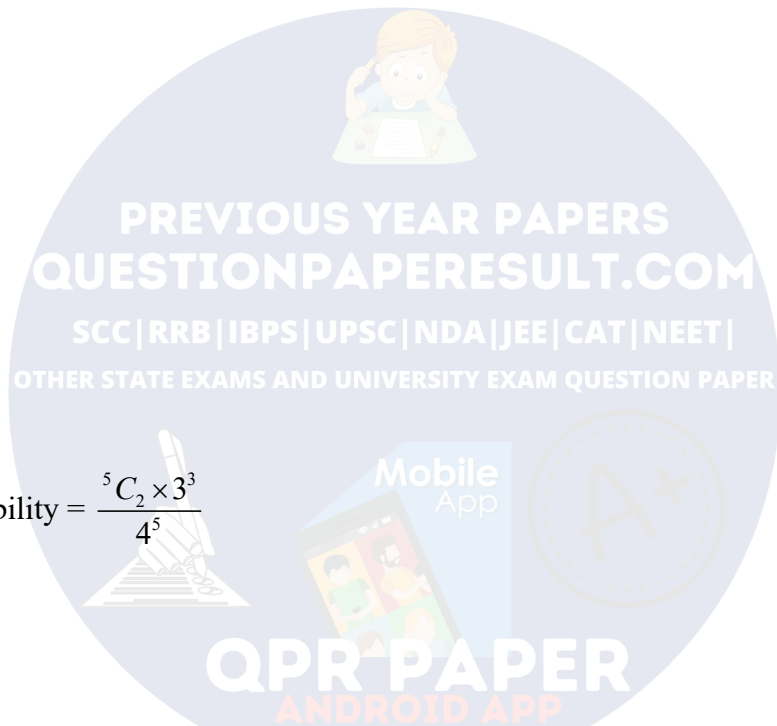
(c) $\frac{35}{2^9}$

(d) $\frac{135}{2^9}$

Answer: (d)

Solution:

$$\begin{aligned} \text{Required probability} &= \frac{{}^5C_2 \times 3^3}{4^5} \\ &= \frac{10 \times 27}{2^{10}} = \frac{135}{2^9} \end{aligned}$$



Question: A curve $y = f(x)$ passing through the point (1, 2) satisfies the differential

equation $x \frac{dy}{dx} + y = bx^4$ such that $\int_1^2 f(y) dy = \frac{62}{5}$. The value of b is

Options:

(a) 10

(b) 11

(c) $\frac{32}{5}$

(d) $\frac{62}{5}$

Answer: (a)

Solution:

$$\frac{dy}{dx} + \frac{y}{x} = 6x^3$$

$$\text{I.F.} = e^{\int \frac{dy}{dx}} = x$$

$$\therefore yx = \int bx^4 dx = \frac{bx^5}{5} + C$$

Passes through (1, 2), we get

$$2 = \frac{b}{5} + C \quad \dots(i)$$

$$\text{Also, } \int_1^2 \left(\frac{bx^4}{5} + \frac{C}{x} \right) dx = \frac{65}{2}$$

$$\Rightarrow \frac{b}{25} \times 32 + C \ln 2 - \frac{b}{25} = \frac{62}{5}$$

$$\Rightarrow C = 0 \quad \& \quad b = 10$$

Question: A curve $y = ax^2 + bx + c$ passing through the point (1, 2) has slope at origin equal to 1, then ordered triplet (a, b, c) may be

Options:

(a) (1, 1, 0)

(b) $\left(\frac{1}{2}, 1, 0\right)$

(c) $\left(-\frac{1}{2}, 1, 1\right)$

(d) (2, -1, 0)

Answer: (a)

Solution:

$$2 = a + b + c \quad \dots(i)$$

$$\frac{dy}{dx} = 2ax + b \Rightarrow \left. \frac{dy}{dx} \right|_{(0,0)} = 1$$

$$\Rightarrow b = 1 \Rightarrow a + c = 1$$

Question: The value of $\int_1^3 [x^2 - 2x - 2] dx$ ([.] denotes greatest integer function)

Options:

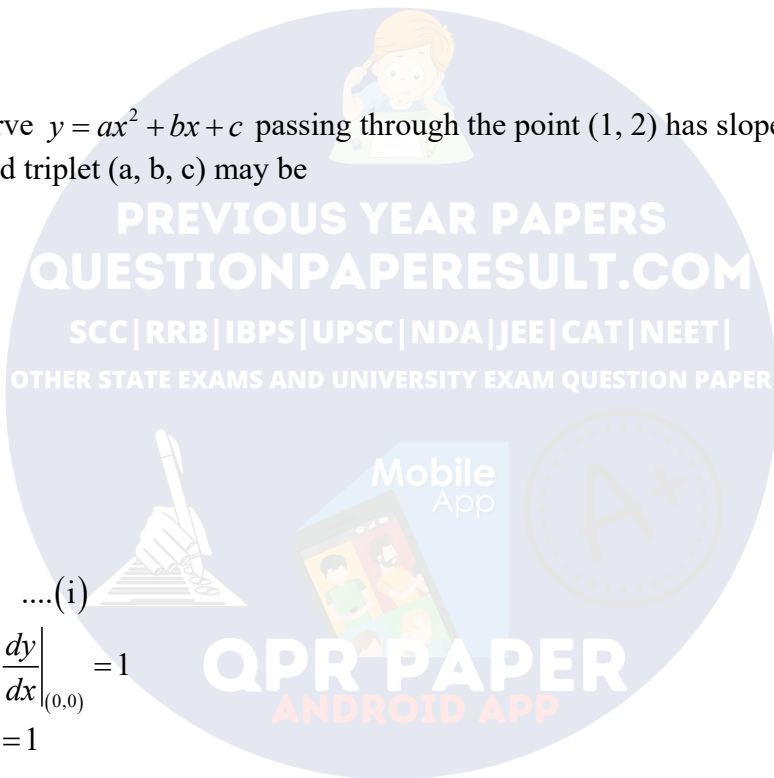
(a) -4

(b) -5

(c) $-1 - \sqrt{2} - \sqrt{3}$

(d) $1 - \sqrt{2} - \sqrt{3}$

Answer: (c)



Solution:

$$I = \int_1^3 -3 dx + \int_1^3 [(x-1)^2] dx$$

Put $x-1=t$; $dx=dt$

$$I = (-6) + \int_0^2 [t^2] dt$$

$$I = (-6) + \int_0^1 0 dt + \int_1^{\sqrt{2}} 1 dt + \int_{\sqrt{2}}^{\sqrt{3}} 2 dt + \int_{\sqrt{3}}^2 3 dt$$

$$I = -6 + (\sqrt{2}-1) + 2\sqrt{3} - 2\sqrt{2} + 6 - 3\sqrt{3}$$

$$I = -1 - \sqrt{2} - \sqrt{3}$$

Question: Which of the following conic has tangent ' $x + \sqrt{3}y - 2\sqrt{3}$ ', at point $\left(\frac{3\sqrt{3}}{2}, \frac{1}{2}\right)$?

Options:

(a) $x^2 + 9y^2 = 9$

(b) $y^2 = \frac{x}{6\sqrt{3}}$

(c) $x^2 - 9y^2 = 10$

(d) $x^2 = \frac{y}{6\sqrt{3}}$

Answer: (a)

Solution:

Tangent to $x^2 + 9y^2 = a$ at point $\left(\frac{3\sqrt{3}}{2}, \frac{1}{2}\right)$ is $x\left(\frac{3\sqrt{3}}{2}\right) + 9y\left(\frac{1}{2}\right) = 9$

Option (a) is true

Question: Equation of plane passing through $(1, 0, 2)$ and line of intersection of planes

$$\vec{r} \cdot (\hat{i} + \hat{j} + \hat{k}) = 1 \text{ and } \vec{r} \cdot (\hat{i} - 2\hat{j}) = -2 \text{ is}$$

Options:

(a) $\vec{r} \cdot (\hat{i} + 7\hat{j} + 3\hat{k}) = 7$

(b) $\vec{r} \cdot (3\hat{i} + 10\hat{j} + 3\hat{k}) = 7$

(c) $\vec{r} \cdot (\hat{i} + \hat{j} - 3\hat{k}) = 4$

(d) $\vec{r} \cdot (\hat{i} + 4\hat{j} - \hat{k}) = -7$

Answer: (a)

Solution:

Plane passing through intersection of plane is

$$\{\vec{r} \cdot (\hat{i} + \hat{j} + \hat{k}) = -1\} + \lambda \{\vec{r} \cdot (\hat{i} - 2\hat{j}) + 2\} = 0$$

Passing through $\hat{i} + 2\hat{k}$, we get

$$(3-1) + \lambda(\lambda+2) = 0 \Rightarrow \lambda = -\frac{2}{3}$$

$$\text{Hence, equation of plane is } 3\{\vec{r} \cdot (\hat{i} + \hat{j} + \hat{k}) - 1\} - 2\{\vec{r} \cdot (\hat{i} - 2\hat{j}) + 2\} = 0$$

$$\Rightarrow \vec{r} \cdot (\hat{i} + 7\hat{j} + 3\hat{k}) = 7$$

Question: A is 3×3 square matrix and B is 3×3 skew symmetric matrix and X is a 3×1 matrix, then equation $(A^2 B^2 - B^2 A^2)X = 0$ (Where O is a null matrix) has/have

Options:

- (a) Infinite solution
- (b) No solution
- (c) Exactly one solution
- (d) Exactly two solution

Answer: (a)

Solution:

$$A^T = A, B^T = -B$$

$$\text{Let } A^2 B^2 - B^2 A^2 = P$$

$$P^T = (A^2 B^2 - B^2 A^2)^T = (A^2 B^2)^T - (B^2 A^2)^T$$

$$= (B^2)^T (A^2)^T - (A^2)^T (B^2)^T$$

$$= B^2 A^2 - A^2 B^2$$

$\Rightarrow P$ is skew-symmetric matrix

$$\Rightarrow |P| = 0$$

Hence $PX = 0$ have infinite solution

Question: Find a point on the curve $y = x^2 + 4$ which is at shortest distance from the line $y = 4x - 1$.

Options:

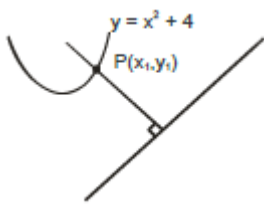
- (a) (2, 8)
- (b) (1, 5)
- (c) (3, 13)
- (d) (-1, 5)

Answer: (a)

Solution:

$$\left. \frac{dy}{dx} \right|_p = 4$$

$$\therefore 2x_1 = 4$$



$$\Rightarrow x_1 = 2$$

\therefore Point will be (2, 8)

Question: Let $f(x) = \begin{cases} -55x & ; x < -5 \\ 2x^3 - 3x^2 - 120x & ; -5 \leq x < 4 \\ 2x^3 - 3x^2 - 36x + 10 & ; x \geq 4 \end{cases}$

Then interval in which $f(x)$ is monotonically increasing is

Options:

(a) $(-5, -4) \cup (4, \infty)$

(b) $(-\infty, -4) \cup (5, \infty)$

(c) $(-5, 4) \cup (5, \infty)$

(d) $(-5, -4) \cup (3, \infty)$

Answer: (a)

Solution:

$$f'(x) = \begin{cases} -55 & ; x < -5 \\ 6(x^2 - x - 20) & ; -5 < x < 4 \\ 6(x^2 - x - 6) & ; x > 4 \end{cases}$$

$$f'(x) = \begin{cases} -55 & ; x < -5 \\ 6(x-5)(x+4) & ; -5 < x < 4 \\ 6(x-3)(x+2) & ; x > 4 \end{cases}$$

Hence, $f(x)$ is monotonically increasing is $(-5, -4) \cup (4, \infty)$

Question: If variance of ten numbers 1, 1, 1, 1, 1, 1, 1, 1, 1, k ; where $k \in N$, is less than or equal to 10 then maximum value of k is.

Answer: 11.00

Solution:

$$\text{var} \leq 10$$

$$\frac{9(1^2) + k^2}{10} - \left(\frac{9+k}{10}\right)^2 \leq 10$$

$$90 + 10k^2 - 81 - k^2 - 18k \leq 1000$$

$$9k^2 - 18k \leq 991$$

$$9k(k-2) \leq 991$$

$$\therefore k \in \mathbb{N}$$

\therefore By hit and trial we observe that max. value of k is 11.

Question: If $a + \alpha = 1, \beta + b = 2$ and $a\left(f(x)\right) + \alpha\left(f\left(\frac{1}{x}\right)\right) = \frac{\beta}{x} + bx$, then find value of

$$\frac{\left[f(x) + f\left(\frac{1}{x}\right)\right]}{x + \frac{1}{x}} =$$

Answer: 2.00

Solution:

Take $a = \alpha = \frac{1}{2}$ and $b = \beta = 1$

Now, $a\left(f(x)\right) + \alpha\left(f\left(\frac{1}{x}\right)\right) = \beta x + \frac{b}{x}$

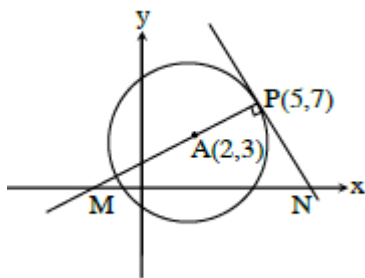
$$\Rightarrow \frac{1}{2}\left[f(x) + f\left(\frac{1}{x}\right)\right] = x + \frac{1}{x}$$

$$\Rightarrow \frac{f(x) + f\left(\frac{1}{x}\right)}{x + \frac{1}{x}} = 2$$

Question: $(x-2)^2 + (y-3)^2 = 25$, Normal and tangent are drawn to it at $(5, 7)$. Area of Δ made by normal, tangent and x -axis is A . Find $24A$.

Answer: 1225.00

Solution:



Equation of normal at $P(5, 7)$

$$y - 7 = \frac{7-3}{5-2}(x-5)$$

$$y - 7 = \frac{4}{3}(x - 5)$$

Put $y = 0$

$$-21 = 4x - 20$$

$$4x = -1$$

$$x = \frac{-1}{4}$$

$$\Rightarrow B\left(\frac{-1}{4}, 0\right)$$

Equation of tangent at $P(5, 7)$

$$y - 7 = \frac{-3}{4}(x - 5)$$

Put $y = 0$

$$-28 = -3x + 15$$

$$\Rightarrow 3x = 43 \Rightarrow x = \frac{43}{3}$$

$$\Rightarrow C\left(\frac{43}{3}, 0\right) \Rightarrow BC = \frac{43}{3} + \frac{1}{4} = \frac{175}{12}$$

$$\text{So, } 24A = 24 \times \frac{1}{2} \times \frac{175}{12} \times 7 = 1225$$

Question: Sum of first four terms of $G.P = \frac{65}{12}$. Sum of their reciprocals is $\frac{65}{18}$. Product of

first 3 terms is 1. If 3rd term is α , $2\alpha =$

Answer: 3.00

Solution:

Let G.P. is

$$\frac{a}{r}, a, ar, ar^2$$

$$\text{Now, } \frac{a}{r} \cdot a \cdot ar = 1 \Rightarrow a^3 = 1 \Rightarrow a = 1$$

$$\text{Also, } \frac{a}{r} + a + ar + ar^2 = \frac{65}{12}$$

$$\Rightarrow \frac{1}{r} + 1 + r + r^2 = \frac{65}{12}$$

$$\Rightarrow \frac{1 + r + r^2 + r^3}{r} = \frac{65}{12} \quad \dots(i)$$

$$\text{And } \frac{r}{a} + \frac{1}{a} + \frac{1}{ar} + \frac{1}{ar^2} = \frac{65}{18}$$

$$\Rightarrow r+1+\frac{1}{r}+\frac{1}{r^2}=\frac{65}{18}$$

$$\Rightarrow \frac{r^3+r^2+r+1}{r^2}=\frac{65}{18} \quad \dots(\text{ii})$$

$$\frac{\text{(i)}}{\text{(ii)}} \Rightarrow \frac{r^2}{r}=\frac{18}{12}$$

$$\Rightarrow r=\frac{3}{2}$$

$$\therefore 3^{\text{rd}} \text{ term} = \alpha = ar = \frac{3}{2}$$

$$\therefore 2\alpha = 3$$

Question: S_1, S_2, \dots, S_{10} are 10 students, in how many ways they can be divided in 3 groups A, B and C such that all groups have atleast one student and C has maximum 3 students.

Answer: 31650.00

Solution:

Case 1: C gets exactly 1 student

$$\Rightarrow {}^{10}C_1 \times (2^9 - 2) = 10 \times 510 = 5100$$

Case 2: C gets exactly 2 students

$$\Rightarrow {}^{10}C_2 \times (2^8 - 2) = 11430$$

Case 3: C gets exactly 3 students

$$\Rightarrow {}^{10}C_3 \times (2^7 - 2) = 15120$$

$$\text{Total number of ways} = 5100 + 11430 + 15120 = 31650$$

Question: $A(5, 0)$ and $B(-5, 0)$ are two points $PA = 3PB$. Then locus of P is a circle with radius 'r'. Then $4r^2 =$

Answer: 525.00

Solution:

Let $P(h, k)$

$$PA = 3PB \Rightarrow PA^2 = 9PB^2$$

$$\Rightarrow (h-5)^2 + k^2 = 9[(h+5)^2 + k^2]$$

$$\Rightarrow h^2 + 25 - 10h + k^2 = 9h^2 + 225 + 90h + 9k^2$$

$$\Rightarrow 8h^2 + 8k^2 + 100h + 200 = 0$$

$$\Rightarrow h^2 + k^2 + \frac{25}{2}h + 25 = 0$$

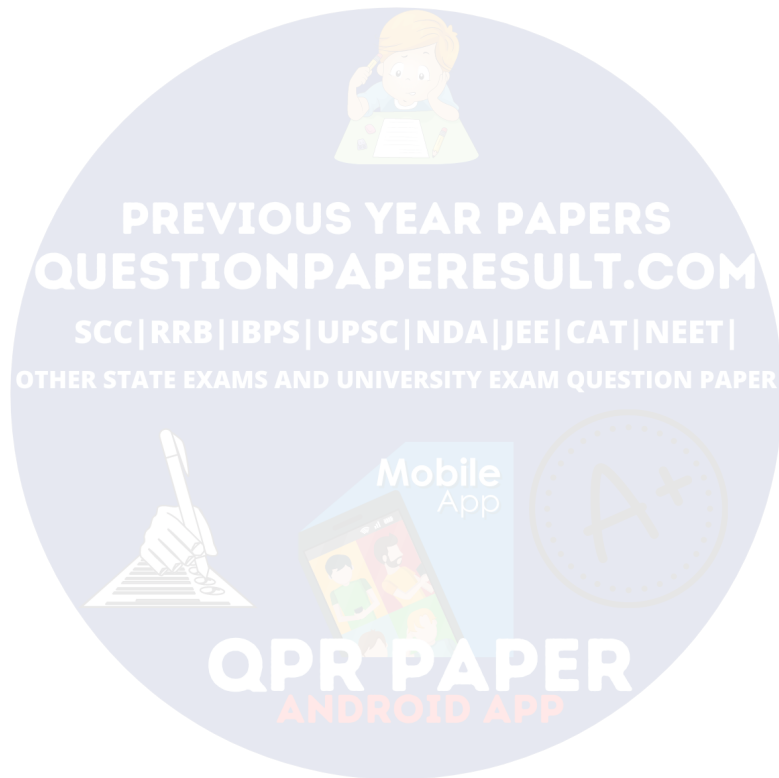
So, locus is

$$x^2 + y^2 + \frac{25}{2}x + 25 = 0$$

$$\text{Its radius} = \sqrt{\left(\frac{25}{4}\right)^2 - 25}$$

$$\Rightarrow r = \sqrt{\frac{622 - 400}{16}} = \frac{15}{4}$$

$$\Rightarrow 4r^2 = 4\left(\frac{225}{16}\right) = \frac{225}{4}$$



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