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E 281 BASEMENT M BLOCK MAIN ROAD GREATER KAILASH 2 NEW DELHI

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IIT JEE PHYSICS PAPER SOLUTION

25 JUNE 2022

EVENING SHIFT

QUESTIONS BASED ON PROJECTILE, CIRCULAR MOTION, DEGREE OF FREEDOM,

PARALLEL PLATE CAPACITOR WITH CONDUCTING PLATE , WAVE OPTICS,AND GATE, MI,CURVED ROAD, RLC CIRCUIT POWER FACTOR

Q61: Given below are two statements. One is labeled as Assertion A and the other is labeled as Reason R.

Assertion A: Two identical balls A and B threw with same velocity u at two different angles with horizontal attained the same range R. If A and B reached the maximum height h_1 and h_2 respectively, then $R = 4\sqrt{h_1 h_2}$

Reason R: Product of said heights.

$h_1 h_2 = \left(\frac{u^2 \sin^2\theta}{2g}\right) \cdot \left(\frac{u^2 \cos^2\theta}{2g}\right)$

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

(B) Both A and R are true but R is NOT the correct explanation of A

(C) A is true but R is false

(D) A is false but R is true.

ANS-61

Relate this question with Que-61

25. A stone projected from ground with certain speed at an angle θ with horizontal attains maximum height h_1. When it is projected with same speed at an angle θ with vertical attains height h_2. The horizontal range of projectile is

(1) $\frac{h_1+h_2}{2}$ (2) $2h_1h_2$ (3) $4\sqrt{h_1h_2}$ (4) $h_1 + h_2$

$\theta, (90-\theta)$

$h_1 = \frac{u^2 \sin^2\theta}{2g} = \frac{u^2 \sin^2\theta}{2g}$

$h_2 = \frac{u^2 \sin^2(90-\theta)}{2g} = \frac{u^2 \cos^2\theta}{2g}$

$\sin 2\theta = 2\sin\theta\cos\theta$

$h_1 h_2 = \frac{u^2 \sin^2\theta \; u^2 \cos^2\theta}{(2g)(2g)} = \frac{u^2 \cdot u^2 \; (\sin\theta\cos\theta)^2 \times 4}{2g \times 2g \times 4}$

$= \frac{u^2 \cdot u^2 \; (2\sin\theta\cos\theta)^2}{4 \times 2 \times 2 \times g \times g} = \frac{u^2 \cdot u^2 \; (\sin 2\theta)^2}{4 \times 2 \times 2 \times g \times g}$

$h_1 h_2 = \frac{u^2 \cdot u^2 \; (2\sin\theta\cos\theta)^2}{4 \times 2 \times 2 \times g \times g}$

$h_1 h_2 = \frac{u^2}{g} \times \frac{u^2}{g} \times \frac{1}{16}$

$h_1 h_2 = (R)(R) \times \frac{1}{16}$

$16(h_1 h_2) = R^2$

$R = 4\sqrt{h_1 h_2}$

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Q62: Two buses P and Q start from a point at the same time and move in a straight line and their positions are represented by $X_P(t) = \alpha t + \beta t^2$ and $X_Q(t) = ft - t^2$. At what time, both the buses have same velocity?

(A) $\frac{\alpha - f}{1+\beta}$

(B) $\frac{\alpha + f}{2(\beta - 1)}$

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

(D) ✓ $\frac{f - \alpha}{2(1+\beta)}$

ANS-62 →

$x_p(t) = \alpha(t) + \beta t^2$

$v_{x_p} = \frac{dx_p t}{dt} = \alpha \frac{dt}{dt} + \beta \frac{d}{dt} t^2 = \alpha + \beta(2t)$

$x_Q(t) = ft - t^2$

$\frac{dx_Q(t)}{dt} = \frac{d}{dt}(ft - t^2)$

$v_{x_Q} = f \frac{dt}{dt} - \frac{d}{dt} t^2 = f - 2t$

$v_{x_p} = v_{x_Q}$

$\alpha + 2\beta t = f - 2t$

$2t(\beta + 1) = f - \alpha \Rightarrow t = \frac{f - \alpha}{2(\beta + 1)}$

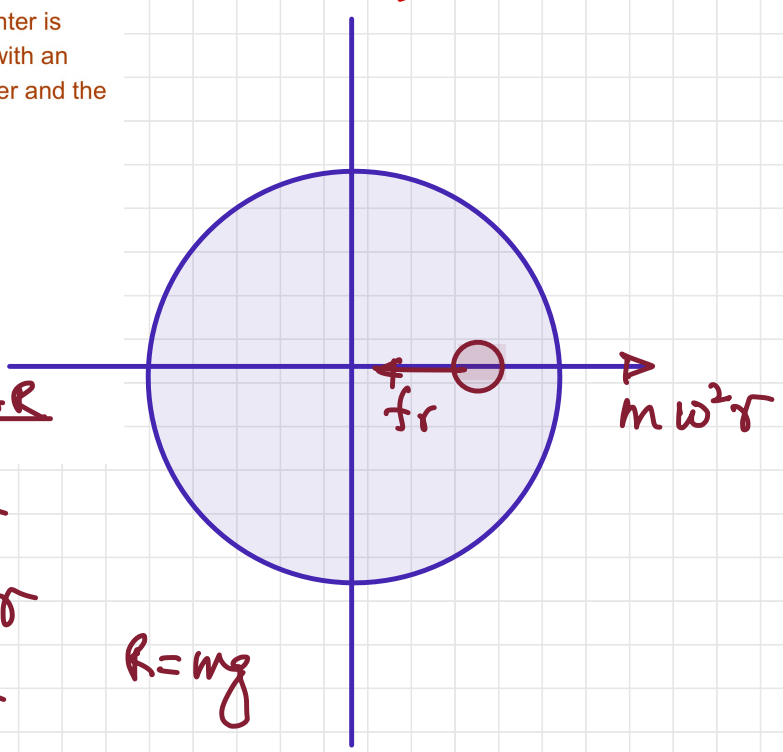
Q63: A disc with a flat small bottom beaker placed on it at a distance R from its center is revolving about an axis passing through the center and perpendicular to its plane with an angular velocity ω. The coefficient of static friction between the bottom of the beaker and the surface of the disc is μ. The beaker will revolve with the disc if :

(A) $r \leqslant \frac{\mu g}{2\omega^2}$

(B) $r \leqslant \frac{\mu g}{\omega^2}$

(C) $r \geqslant \frac{\mu g}{2\omega^2}$

(D) $r \geqslant \frac{\mu g}{\omega^2}$



FOR CIRCULAR MOTION

$f_r \geq m\omega^2 r$

$\mu R \geq m\omega^2 r$

$R = mg$

$\mu mg \geq m\omega^2 r$

$\frac{\mu g}{\omega^2} \geq r$

$r \leq \mu g/\omega^2$

Q64: A solid metallic cube having total surface area $24\ \mathrm{m}^2$ is uniformly heated. If its temperature is increased by $10^\circ C$, calculate the increase in volume of the cube. (Given $\alpha = 5.0 \times 10^{-4^\circ}\mathrm{C}^{-1}$).

(A) $2.4 \times 10^6\ \mathrm{cm}^3$

(B) ✓ $1.2 \times 10^5\ \mathrm{cm}^3$

(C) $6.0 \times 10^4\ \mathrm{cm}^3$

(D) $4.8 \times 10^5\ \mathrm{cm}^3$

ANS-64

$V_t = V_0 (1 + \gamma \Delta T)$

$V_t = V_0 + V_0 \gamma \Delta T$

$V_t - V_0 = V_0 \gamma \Delta T$

$\Delta V = V_0 \gamma \Delta T$

$6l^2 = 24$

$l^2 = 4$

$l = 2\ \mathrm{mt}$

$\Delta V = l^3 (3\alpha) \Delta T$

$= (2)^3 \times 3 \times 5 \times 10^{-4} \times (10)$

$= 1.2 \times 10^5\ \mathrm{cm}^3$

Q65: A copper block of mass 5.0 kg is heated to a temperature of $500^{\circ}C$ and is placed on a large ice block. What is the maximum amount of ice that can melt?
[Specific heat of copper: $0.39\ \mathrm{J\ g^{-1\circ}C^{-1}}$ and latent heat of fusion of water: $335 Jg^{-1}$]

(A) 1.5kg

(B) 5.8 kg

(C) 2.9 kg ✓

(D) 3.8 kg

ANS - 65

Heat given by the block = heat received by the block

$$M_{(Cu)} \times S_{Cu} \times (T-0) = M_{ICE}(L)$$

$$M_{ICE} = \frac{M_{(Cu)}\, S_{(Cu)}\, (T)}{L}$$

$$= \frac{(5)(500)(0.39)}{335}$$

$$= 2.9\,kg$$

Q66: The ratio of specific heats $\left(\frac{C_P}{C_V}\right)$ in terms of degree of freedom (f) is given by:

(A) $\left(1+\frac{f}{3}\right)$

(B) $\left(1+\frac{2}{f}\right)$

(C) $\left(1+\frac{f}{2}\right)$

(D) $\left(1+\frac{1}{f}\right)$

ANS-66

Internal energy for 1 mole of a gas $= U = \frac{f}{2} RdT = C_V dT$

f – degree of freedom

$C_V = \frac{f}{2} R$

$C_P - C_V = R$

$C_P - \frac{f}{2} R = R \Rightarrow C_P = R\left(1+\frac{f}{2}\right)$

$\gamma = \frac{C_P}{C_V} = \frac{R\left(1+\frac{f}{2}\right)}{\left(\frac{f}{2}\right)}$

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

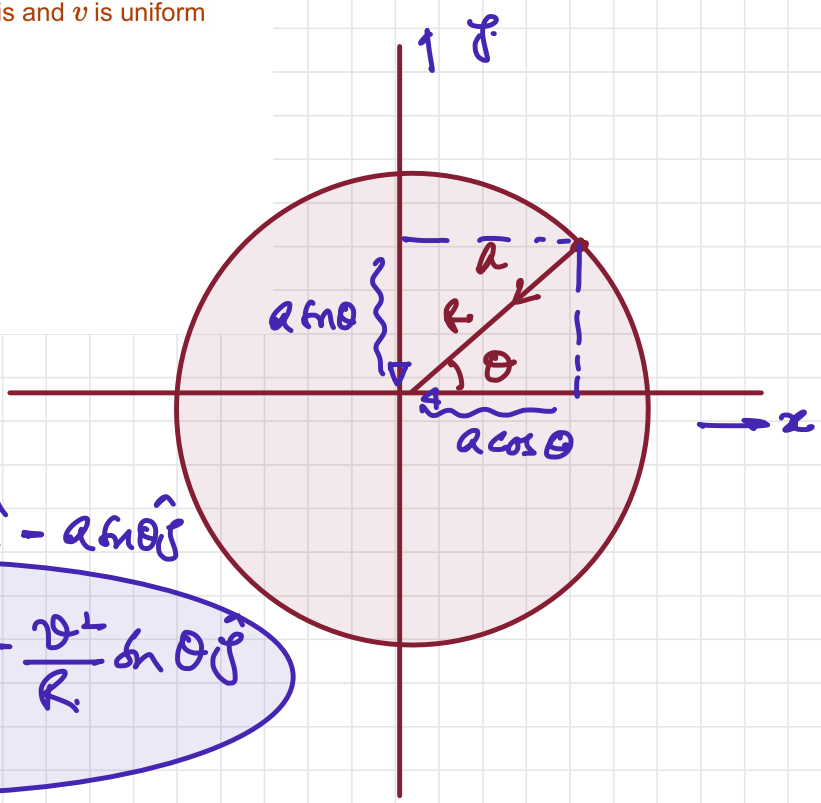
Q67: For a particle in uniform circular motion, the acceleration $\vec{a}$ at any point $P(R, \theta)$ on the circular path of radius R is (when θ is measured from the positive x axis and v is uniform speed) :

(A) $-\frac{v^2}{R}\sin\theta\hat{i} + \frac{v^2}{R}\cos\theta\hat{j}$

(B) $-\frac{v^2}{R}\cos\theta\hat{i} + \frac{v^2}{R}\sin\theta\hat{j}$

(C) $-\frac{v^2}{R}\cos\theta\hat{i} - \frac{v^2}{R}\sin\theta\hat{j}$

(D) $-\frac{v^2}{R}\hat{i} + \frac{v^2}{R}\hat{j}$



$$\vec{a} = -a\cos\theta\,\hat{i} - a\sin\theta\,\hat{j}$$

$$\vec{a} = -\frac{v^2}{R}\cos\theta\,\hat{i} - \frac{v^2}{R}\sin\theta\,\hat{j}$$

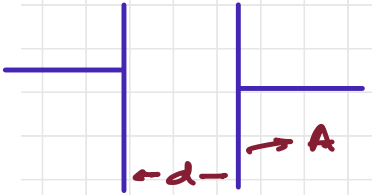
Q68: Two metallic plates form a parallel plate capacitor. The distance between the plate is ' d '. A metal sheet of thickness $\frac{d}{2}$ and of area equal to area of each plate is introduced between the plates. What will be the ratio of the new capacitance to the original capacitance of the capacitor?

(A) 2: 1

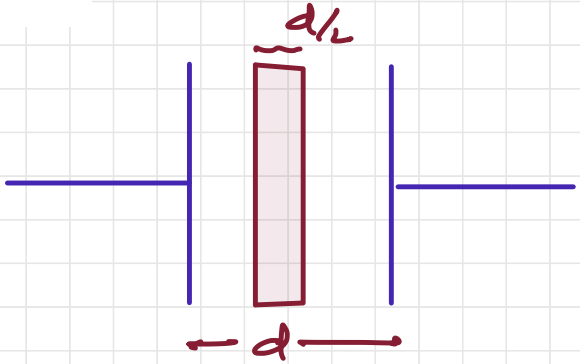
(B) 1: 2

(C) 1: 4

(D) 4: 1



$$C = \frac{\epsilon_0 A}{d}$$



$$C' = \frac{\epsilon_0 A}{d-t} = \frac{\epsilon_0 A}{d-d/2} = \frac{2\epsilon_0 A}{d}$$

$C' = 2C$

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

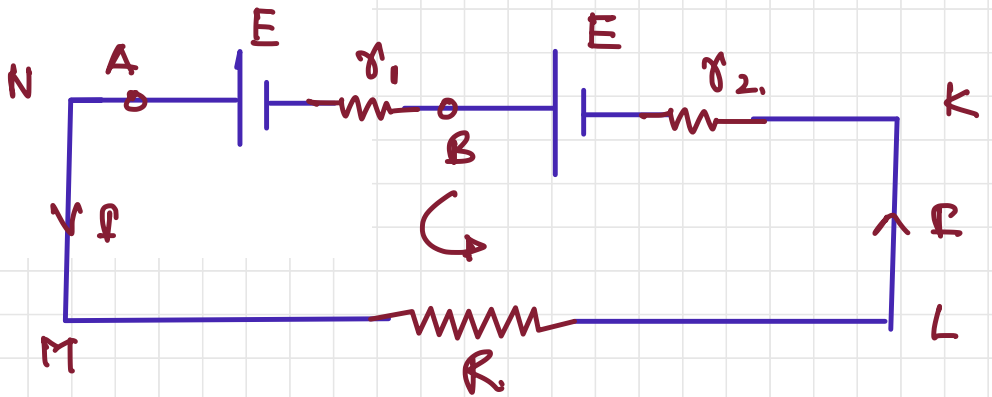
Q69: Two cells of the same emf but different internal resistances r_1 and r_2 are connected in series with a resistance R. The value of resistance R, for which the potential difference across first cell is zero, is:

(A) $r_2 - r_1$

(B) $r_1 - r_2$

(C) r_1

(D) r_2



$V_{AB} = 0$

$= E - I r_1$

$= E - \frac{2E r_1}{R + r_1 + r_2}$

$= E \left\{ \frac{R + r_1 + r_2 - 2r_1}{R + r_1 + r_2} \right\} = E \left\{ \frac{R + r_2 - r_1}{R + r_1 + r_2} \right\} = 0$

$IR + I r_2 - E + I r_1 - E = 0$

$I(R + r_1 + r_2) = 2E$

$I = \frac{2E}{R + r_1 + r_2}$

$R + r_2 - r_1 = 0$

$R = r_1 - r_2$

Q70: Given below are two statements:

Statement - I: Susceptibilities of paramagnetic and ferromagnetic substances increase with decrease in temperature.

Statement - II: Diamagnetism is a result of orbital motions of electrons developing magnetic moments opposite to the applied magnetic field.

Choose the correct answer from the options given below: -

(A) Both Statement - I and Statement - II are true.

(B) Both Statement - I and Statement - II are false.

(C) Statement-I is true but Statement-II is false.

(D) Statement - I is false but Statement - II is true.

ANS-70

STATEMENT-I → TRUE

STATEMENT-II → TRUE

just go trough chapter magnetic properties of material

Q71: A long solenoid carrying a current produces a magnetic field B along its axis. If the current is doubled and the number of turns per cm is halved, the new value of magnetic field will be equal to

(A) B

(B) 2B

(C) 4B

(D) $\frac{B}{2}$

ANS-71

Magnetic field due to solenoid

$\Rightarrow B = \mu_0 n I$

n = number of turns per unit length

Case-I $B_1 = \mu_0 n I = \mu_0 \left(\frac{N}{\ell}\right) I$

Case-II $B_2 = \mu_0 \frac{(N/2)}{\ell} (2I) = \mu_0 \left(\frac{N}{\ell}\right) I$

$B_1 = B_2 = B$

Q72: A sinusoidal voltage $V(t) = 210 \sin 3000t$ volt is applied to a series LCR circuit in which $L = 10\text{mH}, C = 25\mu F$ and $R = 100\Omega$. The phase difference (Φ) between the applied voltage and resultant current will be :

(A) $\tan^{-1}(0.17)$

(B) $\tan^{-1}(9.46)$

(C) $\tan^{-1}(0.30)$

(D) $\tan^{-1}(13.33)$

$$X_C = \frac{1}{\omega C} = \frac{1}{3000 \times 20 \times 10^{-6}}$$

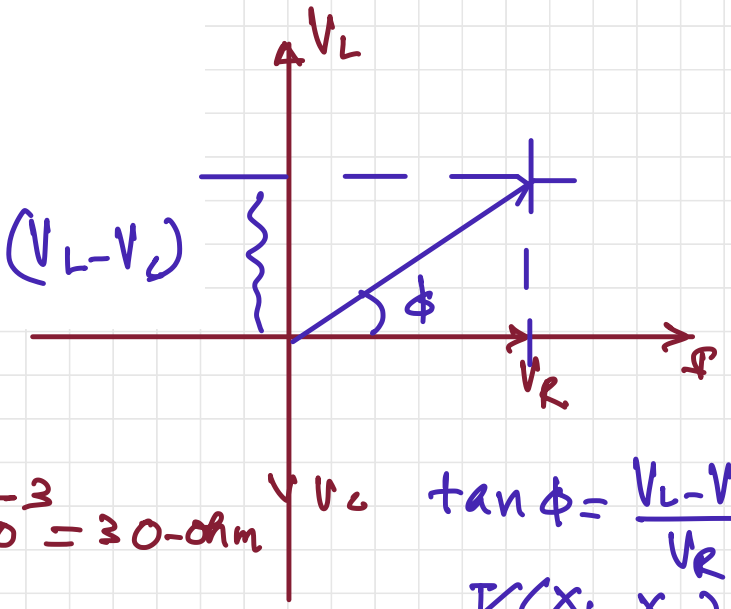
$$= \frac{40}{3} \text{ ohm}$$

$$X_L = \omega L = 3000 \times 10 \times 10^{-3} = 30 \text{ ohm}$$

$$\tan\phi = \frac{X_L - X_C}{R} = \frac{30 - 40/3}{100}$$

$$= \frac{90-40}{100} = \frac{50}{(3)\times 100} = \frac{1}{6}$$

$\tan\phi = 0.17$, $\phi = \tan^{-1}(0.17)$



$$\tan\phi = \frac{V_L - V_C}{V_R} = \frac{I(X_L - X_C)}{IR} = \frac{(X_L - X_C)}{R}$$

Q73: The electromagnetic waves travel in a medium at a speed of 2.0×10^8 m/s. The relative permeability of the medium is 1.0. The relative permittivity of the medium will be :

(A) 2.25

(B) 4.25

(C) 6.25

(D) 8.25

ANS-73

$$v = \frac{1}{\sqrt{\mu \epsilon}}$$

$$v = \frac{1}{\sqrt{\mu_0 \mu_r \epsilon_0 \epsilon_r}}$$

$$= \frac{1}{\sqrt{\mu_0 \epsilon_0}} \left(\frac{1}{\sqrt{\mu_r \epsilon_r}} \right)$$

$$2 \times 10^8 = \frac{3 \times 10^8}{\sqrt{(1)\epsilon_r}}$$

$$\epsilon_r = 9/4$$

Q74: The interference pattern is obtained with two coherent light sources of intensity ratio 4:1. And the ratio $\frac{I_{max}+I_{min}}{I_{max}-I_{min}}$ is $\frac{5}{x}$. Then, the value of x will be equal to:

(A) 3

(B) 4

(C) 2

(D) 1

ANS-74 $\rightarrow$ $\frac{I_1}{I_2} = \frac{a^2}{b^2} = \frac{4}{1}$

$I_{max} = k\left(\sqrt{I_1} + \sqrt{I_2}\right)^2$

$I_{min} = k\left(\sqrt{I_1} - \sqrt{I_2}\right)^2$

$$\frac{I_{max} + I_{min}}{I_{max} - I_{min}} = \frac{k\left(\sqrt{4} + \sqrt{1}\right)^2 + k\left(\sqrt{4} - \sqrt{1}\right)^2}{k\left(\sqrt{4} + \sqrt{1}\right)^2 - k\left(\sqrt{4} - \sqrt{1}\right)^2}$$

$$= \frac{9 + 1}{9 - 1} = \frac{10}{8} = \frac{5}{4}$$

$$\frac{5}{4} = \frac{5}{x}$$

$x = 4$

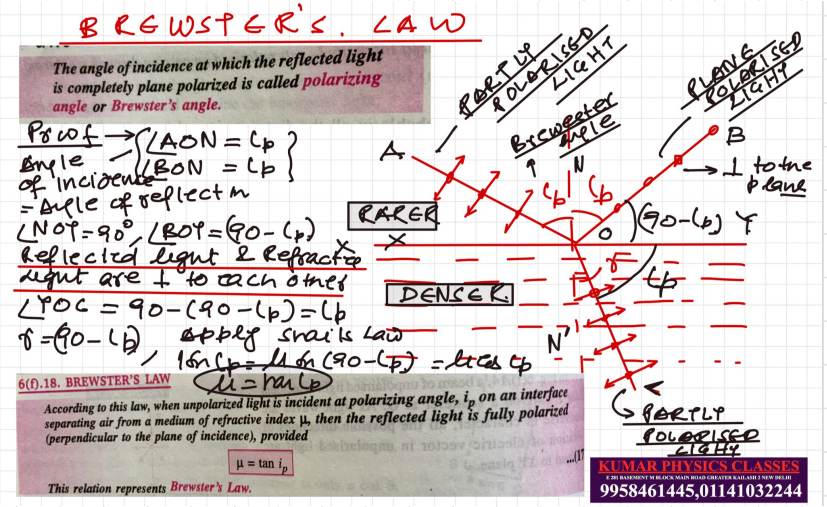
Q75: A light whose electric field vectors are completely removed by using a good polaroid, allowed to incident on the surface of the prism at Brewster's angle. Choose the most suitable option for the phenomenon related to the prism.

(A) Reflected and refracted rays will be perpendicular to each other.

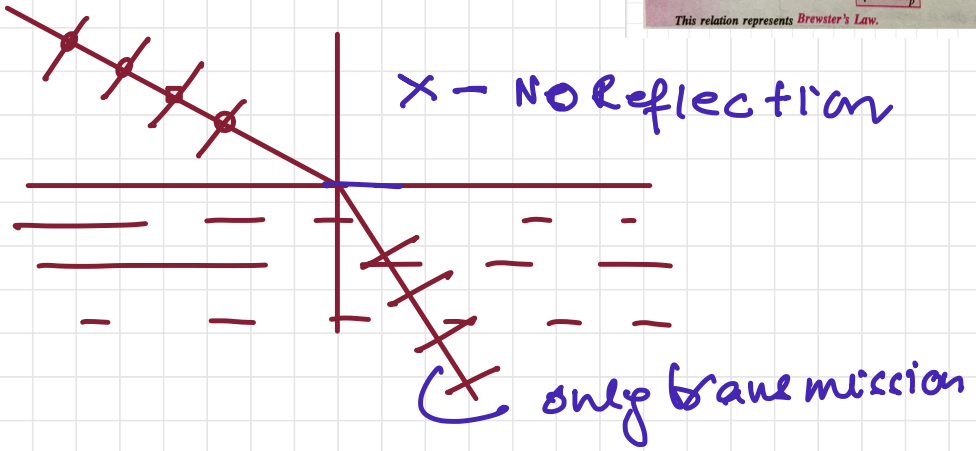
(B) Wave will propagate along the surface of prism

(C) No refraction, and there will be total reflection of light

(D) ✓ No reflection. and there will be total transmission of light



● → electric field vector is removed then No reflection



Q76: A proton, a neutron, an electron and an α—particle have same energy. If $\lambda_p, \lambda_p, \lambda_e$ and λ_α are the de Broglie's wavelengths of proton, neutron, electron and α particle respectively, then choose the correct relation from the following:

(A) $\lambda_p = \lambda_n > \lambda_e > \lambda_\alpha$

(B) $\lambda_a < \lambda_n < \lambda_p < \lambda_e$

(C) $\lambda_e < \lambda_p = \lambda_n > \lambda_\alpha$

(D) $\lambda_e = \lambda_p = \lambda_n = \lambda_\alpha$

ANS-76

$KE = \frac{1}{2} m v^2$

$v = \sqrt{\frac{2(KE)}{m}}$

$\lambda = \frac{h}{mv} = \frac{h}{m\sqrt{\frac{2(KE)}{m}}} = \frac{h}{\sqrt{2m(KE)}}$

$\lambda \propto \frac{1}{\sqrt{m}}$

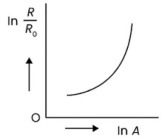
m_e	m_p	m_N	m_α

$m_\alpha > m_N > m_p > m_e$

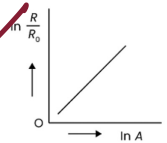
$\lambda_\alpha < \lambda_N < \lambda_p < \lambda_e$

Q77: Which of the following figure represents the variation of $\ln\left(\frac{R}{R_0}\right)$ with $\ln A$(if R = radius of a nucleus and A = its mass number)

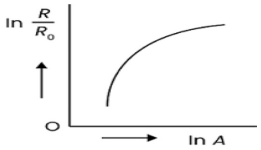
(A)



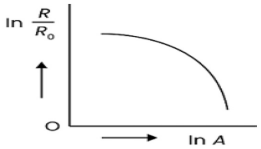
(B)



(C)



(D)



ANS - TT

$R = R_0 A^{1/3}$

$\frac{R}{R_0} = A^{1/3}$

$\log\left(\frac{R}{R_0}\right) = \frac{1}{3}\log(A)$

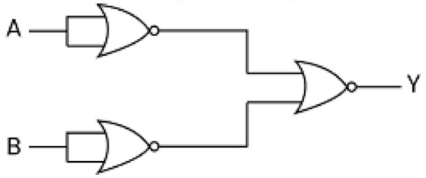
$\log\left(\frac{R}{R_0}\right)$ → y axis

$\log(A)$ → x axis

$y = \frac{1}{3}x$

graph should straight line

Q78: Identify the logic operation performed by the given circuit:



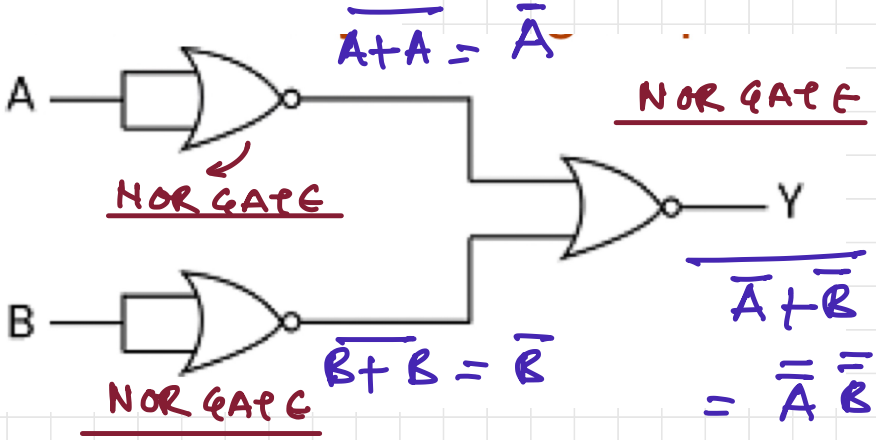
(A) AND gate

(B) OR gate

(C) NOR gate

(D) NAND gate

ANS-78



Note → In the above question all the NOR gate is converted in to NOT gate because their input is same.

Q79: Match List I with List II

List I	List II
A. Facsimile	I. Static Document Image
B. Guided media Channel	II. Local Broadcast Radio
C. Frequency Modulation	III. Rectangular Wave
D. Digital Signal	IV. Optical Fiber

Choose the correct answer from the following options:

(A) $A \to IV, B \to III, C \to II, D \to I$

(B) $A \to I, B \to IV, C \to II, D \to III$

(C) $A \to IV, B \to II, C \to III, D \to I$

(D) $A \to I, B \to II, C \to III, D \to IV$

FACCSIMILE

also known as FAX.
(STATIC DOCUMENT IMAGE)

GUIDED MEDIA CHANNEL

↓

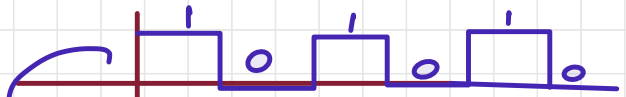
optical fiber

FREQUENCY MODULATION

↓

LOCAL BROADCAST RADIO
(FM)

DIGITAL SIGNAL



Rectangular wave

Q80: If $n$represents the actual number of deflections in a converted galvanometer of resistance G and shunt resistance S. Then the total current I when its figure of merit is K will be:

(A) $\frac{KS}{(S+G)}$

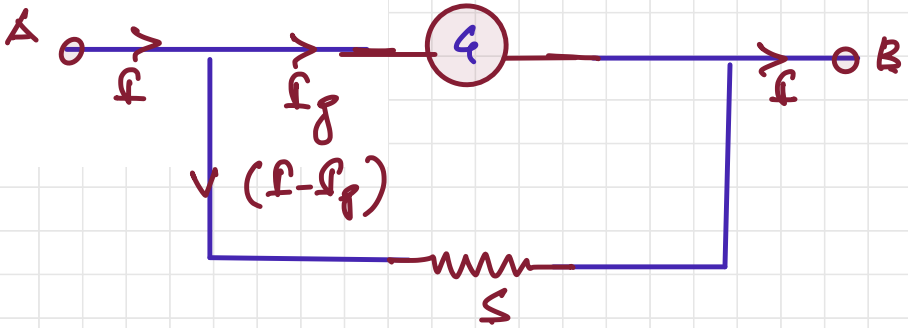
(B) $\frac{(G+S)}{nKS}$

(C) $\frac{nKS}{(G+S)}$

(D) ✓ $\frac{nK(G+S)}{S}$

figure of merit

$K = I_g/n$.



$I_g(G) = (I - I_g)S$

$I_g(G) = IS - I_g(S)$

$I_g(G+S) = IS$

$I_g = \left(\frac{IS}{G+S}\right)$

$Kn = \frac{IS}{G+S}$

$I = \frac{nK(G+S)}{S}$

Q81: For $z = a^2 x^3 y^{\frac{1}{2}}$,where 'a' is a constant. If percentage error in measurement of 'x' and 'y' are 4% and 12%, respectively, then the percentage error for 'z' will be 18 %

18%

ANS- B1

$$z = a^2 x^3 y^{1/2}$$

$$\frac{\Delta z}{z} \times 100\% = 2\frac{\Delta a}{a} \times 100\% + 3\frac{\Delta x}{x} \times 100\% + \frac{1}{2}\frac{\Delta y}{y} \times 100\%$$

$$= 0 + 3(4\%) + \frac{1}{2}(12)$$

$$= 12\% + 6\%$$

$$= 18\%$$

Q82: A curved in a level road has a radius 75 m. The maximum speed of a car turning this curved road can be 30 m/s without skidding. If radius of curved road is changed to 48 m and the coefficient of friction between the tyres and the road remains same, then maximum allowed speed would be m/s.

24 m/s

$$\mu R = \frac{mv^2}{r}$$

$$\mu = \tan\theta$$

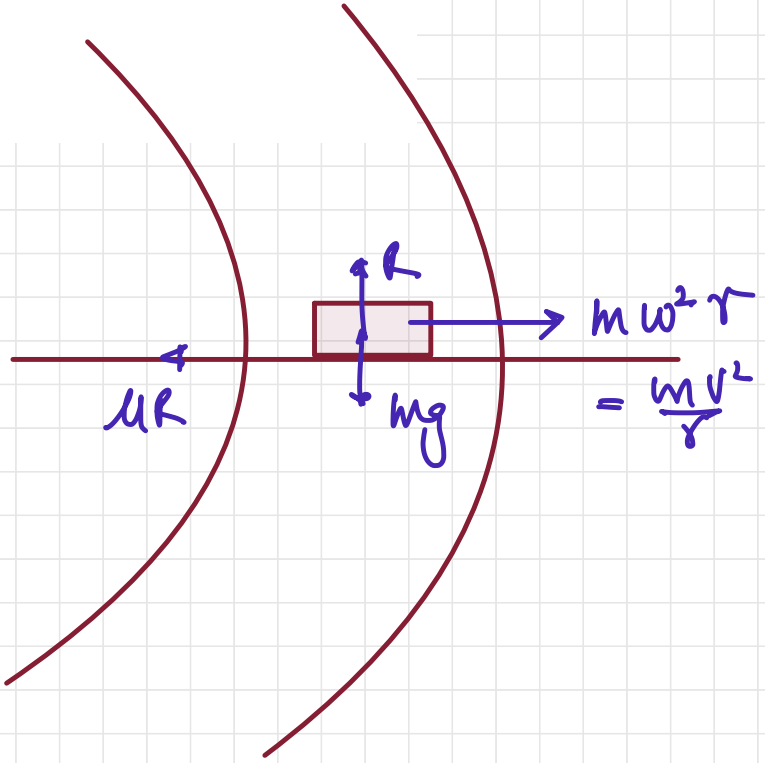
$$(\tan\theta)(mg) = \frac{mv^2}{r}$$

$$\tan\theta = \frac{v^2}{rg}$$

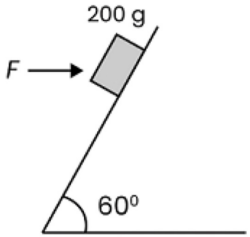
$$v^2 = rg\tan\theta, \quad v \propto \sqrt{r}$$

$$\frac{v_2}{v_1} = \frac{\sqrt{r_2}}{\sqrt{r_1}} = \sqrt{\frac{48}{75}}$$

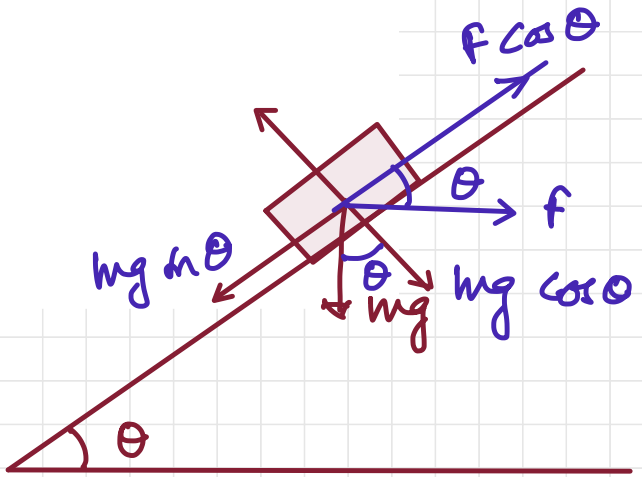
$$v_2 = \frac{4}{5} \times 30 = 24 \text{ mt/sec}$$



Q83: A block of mass 200g is kept stationary on a smooth inclined plane by applying a minimum horizontal force $F = \sqrt{x}N$ as shown in figure.



The value of x = 12



under equilibrium condition

$f\cos\theta = mg\sin\theta$

$f = mg\tan\theta = 200\times10\times\sqrt{3}\times10^{-3}$

$= 2\sqrt{3} = \sqrt{12}\ N$

$\sqrt{12} = \sqrt{x}$

$x = 12$

Q84: Momentum of inertia (M.I) of four bodies having same mass 'M' and radius '2R' as follows:

I_1 =M.I. of solid sphere about its diameter

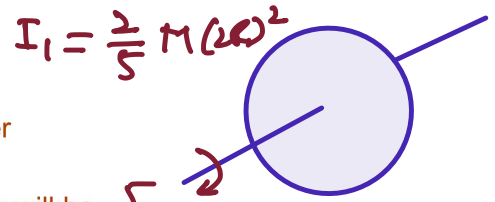
I_2 =M.I of solid cylinder about its axis

I_3 =M.I of solid circular disc about its diameter

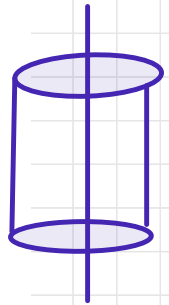
I_4 =M.I of thin circular ring about its diameter

If $2(I_2 + I_3) + I_4 = x.I_1$ then the value of x will be 5

5



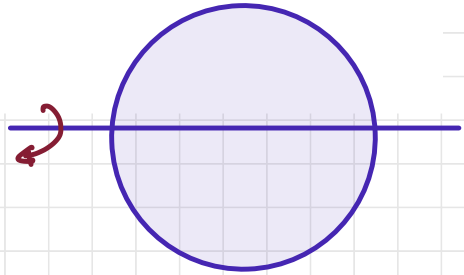
$I_1 = \frac{2}{5}M(2R)^2$



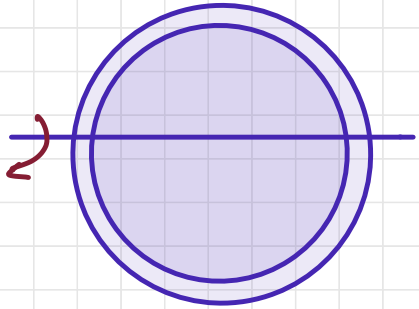
$I_2 = \frac{M(2R)^2}{2}$

$2(I_2 + I_3) + I_4 = xI_1$

$2\left[\frac{M(2R)^2}{2} + \frac{M(2R)^2}{4}\right] + \frac{M(2R)^2}{2} = x\left(\frac{2}{5}M(2R)^2\right)$



$I_3 = \frac{M(2R)^2}{4}$



$I_4 = \frac{M(2R)^2}{2}$

$2\left(\frac{1}{2} + \frac{1}{4}\right) + \frac{1}{2} = \frac{2x}{5}$

$1 + 1/2 + 1/2 = \frac{2x}{5}$

$x = 2x/5 \Rightarrow x = 5$

Q85: Two satellites S_1 and S_2 are revolving in circular orbits around a planet with radius $R_1 = 3200km$ and $R_2 = 800\ km$ respectively. The ratio of speed of satellite S_1 to the speed of satellite S_2 in their respective orbits would be $\frac{1}{x}$ where x =

V_2

$$f_g = f_m$$

$$\frac{GMm}{r^2} = \frac{mv^2}{r}$$

$$v = \sqrt{\frac{GM}{r}}$$

$$v \propto \frac{1}{\sqrt{r}}$$

$$\frac{v_1}{v_2} = \sqrt{\frac{r_2}{r_1}} = \sqrt{\frac{800}{3200}}$$

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