JEE Main 2022 Question Paper with Solutions for July 25 Morning Session (Shift 1)

EASY PAPER

$D = \epsilon_0 E$

↓ ELECTRIC DISPLACEMENT

IIT JEE PHYSICS PAPER SOLUTION 25 JULY 2022 MORNING SHIFT

QUESTIONS BASED ON ELECTRIC DISPLACEMENT, AVG KINETIC ENERGY,LOGIC GATE ,CHARGE DENSITY ARE TRICKY

KUMAR PHYSICS CLASSES

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

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Q61: If momentum [P], area [A] and time [T] are taken as fundamental quantities, then the dimensional formula for coefficient of viscosity is :

(A) $[PA^{-1}T^{0}]$ ✓

(B) $[PAT^{1}]$

(C) $[PA^{-1}T]$

(D) $[PA^{-1}T^{-1}]$

$$\eta = k\,[p]^a\,[A]^b\,[T]^c$$

$$p = mv = MLT^{-1}$$

$$ML^{-1}T^{-1} = k\,[MLT^{-1}]^a\,[L^2]^b\,[T]^c$$

$$= k\,[M]^a\,[L^{a+2b}]\,[T^{-a+c}]$$

$A \to L^2$

$T \to T$

$\eta \to ML^{-1}T^{-1}$

$a = 1, \quad a + 2b = -1, \quad -a + c = -1$

$$1 + 2b = -1$$
$$2b = -2$$
$$b = -1$$

$$-1 + c = -1$$
$$c = 0$$

$$\eta = k\,[p]^1\,[A]^{-1}\,[T]^0$$

Q62: Which of the following physical quantities have the same dimensions?

(A) Electric displacement $(\vec{D})$ and surface charge density

(B) Displacement current and electric field

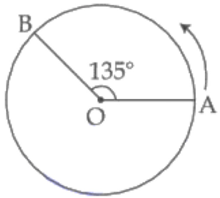
(C) Current density and surface charge density

(D) Electric potential and energy

$D = \epsilon_0 E = \epsilon_0 \frac{\sigma}{\epsilon_0}$

$D = \sigma$

Q63: A person moved from A to B on a circular path as shown in figure. If the distance travelled by him is 60 m, then the magnitude of displacement would be : (Given $\cos 135^\circ = -0.7$)

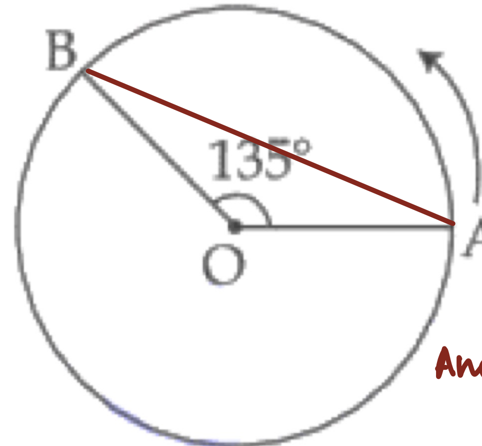


(A) 42 m

(B) 47 m ✓

(C) 19 m

(D) 40 m



Displacement

$$= \sqrt{R^2 + R^2 - 2R^2 \cos 135}$$

$$= \sqrt{2R^2(1 - \cos 135)}$$

$$= \sqrt{2R^2(1 + 0.707)}$$

$$= \sqrt{2R^2(1.707)}$$

$$= 1.84R$$

$$= \frac{80}{3.14} \times 1.84$$

$$= 47 \text{ mt}$$

$$\text{Angle} = \frac{\text{arc}}{\text{radius}}$$

$$\frac{3\pi}{4} = \frac{\text{arc}}{R}$$

$$\text{ARC} = R\left(\frac{3\pi}{4}\right)$$

$$R = \frac{80}{\pi} \text{ mt}$$

Q64: A body of mass 0.5 kg travels on straight line path with $v = (3x^2 + 4)$ m/sec velocity.
The net work done by the force during its displacement from x = 0 to x = 2m is:

(A) 64 J
(B) 60 J
(C) 120 J
(D) 128 J

work done

$= (K_f - K_i)$

$v = 3x^2 + 4$

$v_i = 3(0) + 4 = 4\ m s^{-1}$

$v_f = 3(2)^2 + 4 = 16\ m s^{-1}$

$\Delta W = \frac{1}{2} m \left[(16)^2 - (4)^2 \right]$

$= \frac{1}{2} \times (0.5)(16+4)(16-4)$

$= 60\ J$

Q65: A solid cylinder and a solid sphere, having same mass M and radius R, roll down the same inclined plane from top without slipping. They start from rest. The ratio of velocity of the solid cylinder to that of the solid sphere, with which they reach the ground, will be :

(A) $\sqrt{\frac{5}{3}}$

(B) $\sqrt{\frac{4}{5}}$

(C) $\sqrt{\frac{3}{5}}$

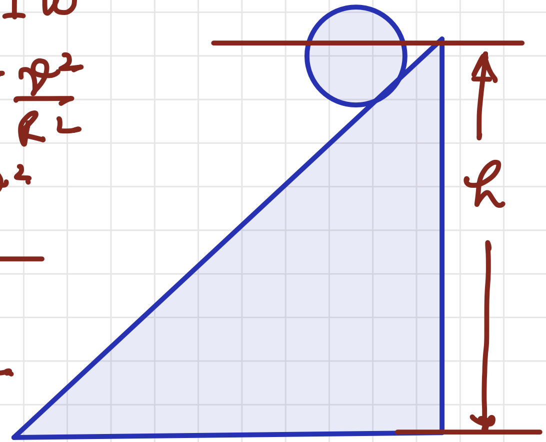
(D) $\sqrt{\frac{14}{15}}$ ✓

$$mgh = \frac{1}{2}mv^2 + \frac{1}{2}I\omega^2$$

$$mgh = \frac{1}{2}mv^2 + \frac{1}{2}mK^2\frac{v^2}{R^2}$$

$$2gh = v^2 + \frac{K^2}{R^2}v^2$$

$$v = \sqrt{\frac{2gh}{1+K^2/R^2}}$$



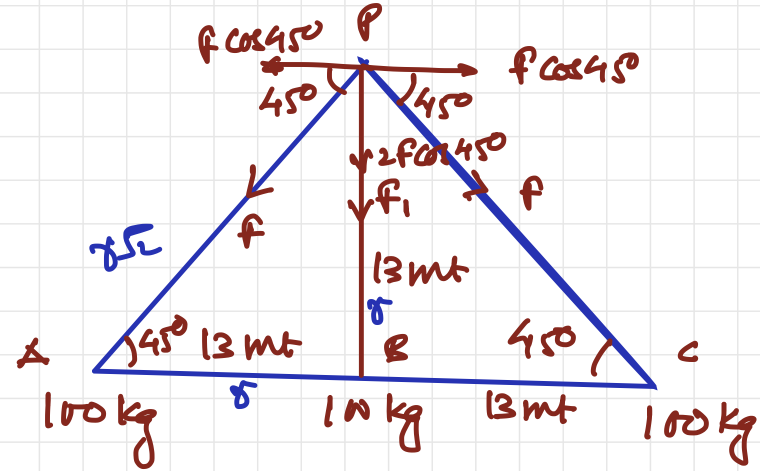
$$\frac{v_{cylinder}}{v_{sphere}} = \frac{\sqrt{\left(1+\frac{K^2}{R^2}\right)_{sphere}}}{\sqrt{\left(1+\frac{K^2}{R^2}\right)_{cylinder}}}$$

$$= \sqrt{\frac{1+2/5}{1+1/2}} = \sqrt{\frac{7}{5}\times\frac{2}{3}}$$

$$= \sqrt{14/15}$$

Q66: Three identical particle A, B and C of mass 100 kg each are placed in a straight line with AB = BC = 13 m. The gravitational force on a fourth particle P of the same mass is F, when placed at a distance 13 m from the particle B on the perpendicular bisector of the line AC. The value of F will be approximately:

(A) 21 G
✓ (B) 100 G
(C) 59 G
(D) 42 G



$$F_{NET} = 2F\cos 45^\circ + F_1$$

$$= 2\left(\frac{GMM}{(r\sqrt{2})^2}\right)\left(\frac{1}{\sqrt{2}}\right) + \frac{GMM}{r^2}$$

$$= \frac{GMM}{r^2}\left(1 + \frac{1}{\sqrt{2}}\right)$$

$$= \frac{G\times 10^4}{(13)^2}\left(1 + \frac{1}{\sqrt{2}}\right) \simeq 100\,G$$

Q67: A certain amount of gas of volume V at. 27°c temperature and pressure $2 \times 10^{7} Nm^{-2}$ expands isothermally until its volume gets doubled. Later it expands adiabatically until its volume gets redoubled. The final pressure of the gas will be (Use) $\gamma = 1.5)$

(A) $3.536 \times 10^{5} Pa$

(B) $3.536 \times 10^{6} Pa$ ✓

(C) $1.25 \times 10^{6} Pa$

(D) $1.25 \times 10^{5} Pa$

$P_1 = 2 \times 10^7 N/m^2$

$P_1 V_1 = P_2 V_2$

$V_2 = 2V$ Hence $P_2 = P_1/2$

$P_2 (V_2)^\gamma = P_3 (2V_2)^\gamma$

$$P_3 = \frac{1 \times 10^7}{(2)^{1.5}} = 3.536 \times 10^6 Pa$$

Q68: Following statements are given:
(1) The average kinetic energy of a gas molecule decreases when the temperature is reduced.
(2) The average kinetic energy of a gas molecule increases with increase in pressure at constant temperature.
(3) The average kinetic energy of a gas molecule decreases with increases in volume.
(4) Pressure of a gas increases with increase in temperature at constant pressure.
(5) The volume of gas decreases with increase in temperature. Choose the correct answer from the options given below:
(A) (1) and (4) only ✓
(B) (1), (2) and (4) only
(C) (2) and (4) only
(D) (1), (2) and (5) only

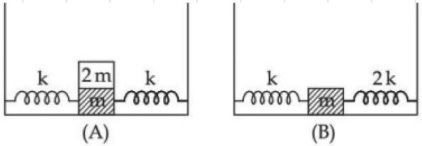
$$(KE)_{avg} = \frac{3}{2} KT$$

$$P = \frac{1}{3} \rho V_{rms}^2$$

(4) — CORRECT
consider constant volume
and not constant pressure.

(But most appropriate
answer is option A)

Q69: In figure (A), mass '2 m' is fixed on mass 'm' which is attached to two springs of spring constant k. In figure (B), mass 'm' is attached to two spring of spring constant 'k' and '2k'. If mass 'm' in (A) and (B) are displaced by distance 'x' horizontally and then released, then time period and corresponding to (A) and (B) respectively follow the relation.



(A) $\frac{T_1}{T_2} = \frac{3}{\sqrt{2}}$ ✓

(B) $\frac{T_1}{T_2} = \sqrt{\frac{3}{2}}$

(C) $\frac{T_1}{T_2} = \sqrt{\frac{2}{3}}$

(D) $\frac{T_1}{T_2} = \frac{\sqrt{2}}{3}$

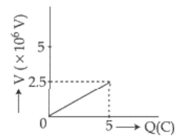
$$T_1 = 2\pi\sqrt{\frac{3m}{2K}}$$

$$T_2 = 2\pi\sqrt{\frac{m}{2K}}$$

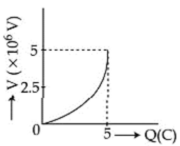
$$\frac{T_1}{T_2} = \frac{2\pi\sqrt{\frac{3m}{2K}}}{2\pi\sqrt{\frac{m}{2K}}} = \frac{3}{\sqrt{2}}$$

Q70: A condenser of capacitance is charged steadily from 0 to 5C. Which of the following graph represents correctly the variation of potential difference (V) across it's plates with respect to the charge (Q) on the condenser?

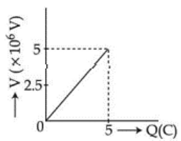
(A) ✓



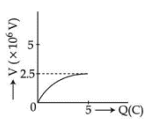
(B)



(C)



(D)



$Q = CV$

$V = \frac{Q}{C}$

$V = \left(\frac{1}{C}\right) Q$

straight line with slope $1/C$

$\text{slope} = \frac{1}{C} = \frac{1}{2\times10^{-6}} = 5\times10^{5}$

Q71: Two charged particles, having same kinetic energy, are allowed to pass through a uniform magnetic field perpendicular to the direction of motion. If the ratio of radii of their circular paths is 6 : 5 and their respective masses ratio is 9 : 4. Then, the ratio of their charges will be :

(A) 8 : 5

(B) 5 : 4 ✓

(C) 5 : 3

(D) 8 : 7

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

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

$$qvB = \frac{mv^2}{r} \Rightarrow r = \frac{mv}{qB}$$

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

$$\frac{q_1}{q_2} = \sqrt{\frac{m_1}{m_2}} \times \frac{R_2}{R_1} = \sqrt{\frac{9}{4}} \times \frac{5}{6} = \frac{5}{4}$$

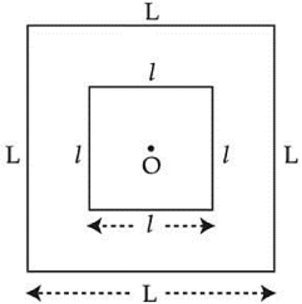
Q72: To increase the resonant frequency in series LCR circuit,
(A) Source frequency should be increased
(B) Another resistance should be added in series with the first resistance.
✓(C) Another capacitor should be added in series with the first capacitor
(D) The source frequency should be decreased

$$f = \frac{1}{2\pi\sqrt{LC}}$$

increase $f\uparrow$, $L\downarrow$, $C\downarrow$

For capacitor to decrease insert another capacitor is in series with the circuit

Q73: A small square loop of wire of side l is placed inside a large square loop of wire $L\,(L \gg l)$. Both loops are coplanar and their centres coincide at point O as shown in figure. The mutual inductance of the system is:



(A) $\frac{2\sqrt{2}\mu_0 L^2}{\pi l}$

(B) $\frac{\mu_0 l^2}{2\sqrt{2}\pi L}$

(C) $\frac{2\sqrt{2}\mu_0 l^2}{\pi L}$ ✓

(D) $\frac{\mu_0 L^2}{2\sqrt{2}\pi l}$

$$\phi = B \cdot A$$

$$MI = 4\left(\frac{\mu_0}{4\pi}\frac{I}{(L/2)}\{\sin 45 + \sin 45\}\right) \times l^2$$

$$M = \frac{\mu_0\, 2}{L\pi}\left(\frac{2}{\sqrt{2}}\right) l^2$$

$$= \frac{2\sqrt{2}\,\mu_0 l^2}{L\pi}$$

Q74: The rms value of conduction current in a parallel plate capacitor is 6.9 μA. The capacity of this capacitor, if it is connected to 230 V ac supply with an angular frequency of 600 rad/s, will be :

(A) $5pF$

(B) $50pF$ ✓

(C) $100pF$

(D) $200pF$

$$I = \frac{V}{X_c} = \frac{V}{(1/\omega C)} = V(\omega C)$$

$$C = \frac{I}{V\omega} = \frac{6.9 \times 10^{-6}}{230 \times 600}$$

$$= 50\,pF$$

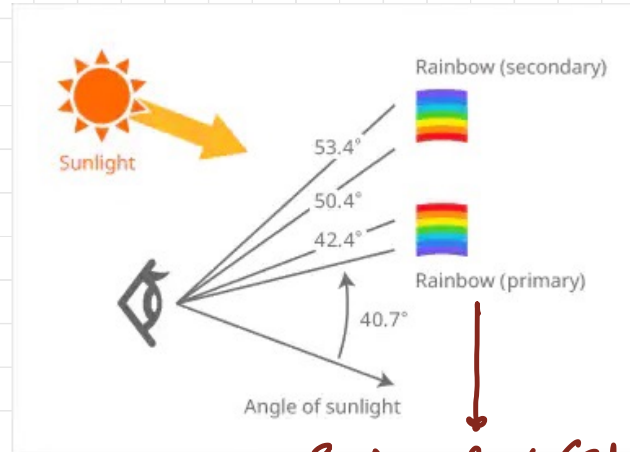
Q75: Which of the following statement is correct?

(A) In primary rainbow, observer sees red colour on the top and violet on the bottom ✓

(B) In primary rainbow, observer sees violet colour on the top and red on the bottom

(C) In primary rainbow, light wave suffers total internal reflection twice before coming out of water drops

(D) Primary rainbow is less bright than secondary rainbow



Red color (at top)

Violet (bottom)

Intensity of secondary rainbow is less than primary rainbow

Q76: Time taken by light to travel in two different materials A and B of refractive indices μ_A and μ_B of same thickness is t_1 and t_2 respectively. If $t_2 - t_1 = 5 \times 10^{-10} s$ and the ratio of μ_A to μ_B is 1 : 2. Then the thickness of material, in meter is : (Given v_A and v_B are velocities of light in A and B materials respectively).

(A) ✓ $5 \times 10^{-10} v_a m$

(B) $5 \times 10^{-10} m$

(C) $1.5 \times 10^{-10} m$

(D) $5 \times 10^{-10} v_B m$

$$\frac{\mu_A}{\mu_B} = \frac{c/v_A}{c/v_B} = \frac{v_B}{v_A} = \frac{1}{2}$$

Let the thickness be x

$$\frac{x}{v_B} - \frac{x}{v_A} = 5 \times 10^{-10}$$

$$x = 5 \times 10^{-10} \left(\frac{v_A v_B}{v_A - v_B} \right)$$

$$v_A = 2v_B \Rightarrow x = 5 \times 10^{-10} \times 2 v_B$$

$$= 5 \times 10^{-10} v_A$$

Q77: A metal exposed to light of wavelength 800 nm and emits photoelectrons with a certain kinetic energy. The maximum kinetic energy of photo-electron doubles when light of wavelength 500 nm is used. The work function of the metal is (Take hc = 1230 eV-nm).

(A) 1.537 eV
(B) 2.46 eV
(C) 0.615 eV ✓
(D) 1.23 eV

$$h\nu = W_0 + (KE)$$

$$h\nu = h\nu_0 + (KE)$$

$$KE = h\nu - h\nu_0 = h\nu - W_0$$

$$(KE)_2 = 2(KE_1)$$

$$(KE)_1 = \frac{1230}{800} - W_0$$

$$(KE)_2 = \frac{1230}{500} - W_0$$

$$\frac{1230}{500} - W_0 = 2\left(\frac{1230}{800} - W_0\right)$$

$$W_0 = 0.615 \text{ eV}$$

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Q78: The momentum of an electron revolving in usual meanings)

(A) $\frac{nh}{2\pi r}$

(B) $\frac{nh}{2r}$

(C) $\frac{nh}{2\pi}$ ✓

(D) $\frac{2\pi r}{nh}$

$$mvr = \frac{nh}{2\pi}$$

Bohr's 2ND Postulate

Q79: The magnetic moment of an electron (e) revolving in an orbit around nucleus with an orbital angular momentum is given by :

(A) $\vec{\mu}_L = \frac{2\vec{L}}{2m}$

(B) $\vec{\mu}_L = \frac{e\vec{L}}{2m}$ ✓

(C) $\vec{\mu}_1 = \frac{e\vec{L}}{m}$

(D) $\vec{\mu}_1 = \frac{2e\vec{L}}{m}$

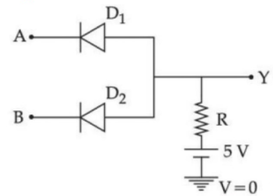
Ratio of $\frac{\text{magnetic moment}}{\text{Angular moment}}$

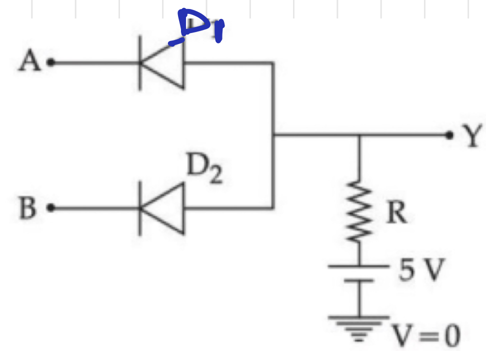
$$\frac{\mu}{L} = \frac{1}{2m}$$

For e^-

$$\mu = -\frac{e}{2m}\vec{L}$$

Q80: In the circuit, the logical value of A = 1 or B = 1 when potential at A or B is 5V and the logical value of A = 0 or B = 0 when potential at A or B is 0 V.





AND GATE

The truth table of the given circuit will be :

(A) ✓

A	B	Y
0	0	0
1	0	0
0	1	0
1	1	1

(B)

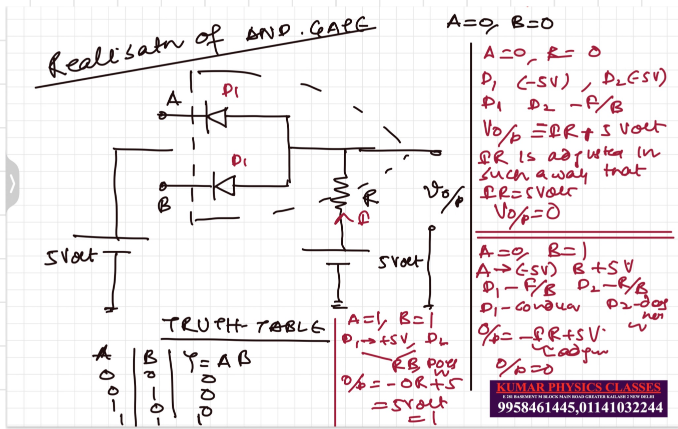
A	B	Y
0	0	0
1	0	1
0	1	1
1	1	1

(C)

A	B	Y
0	0	0
1	0	0
0	1	0
1	1	0

(D)

A	B	Y
0	0	1
1	0	1
0	1	1
1	1	0



Q81: A car is moving with speed of 150 km/h and after applying the brake it will move 27 m before it stops. If the same car is moving with a speed of one third the reported speed then it will stop after travelling ___3___ m distance.

$$v^2 = u^2 + 2(a)(s)$$

$$(0)^2 = u^2 - 2a(s)$$

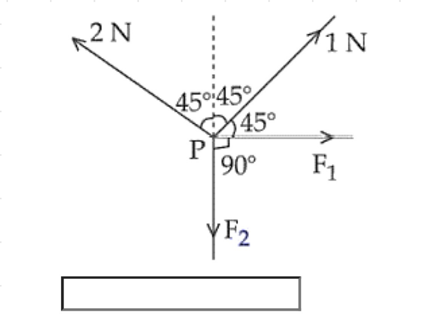
$$s = \frac{u^2}{2a}$$

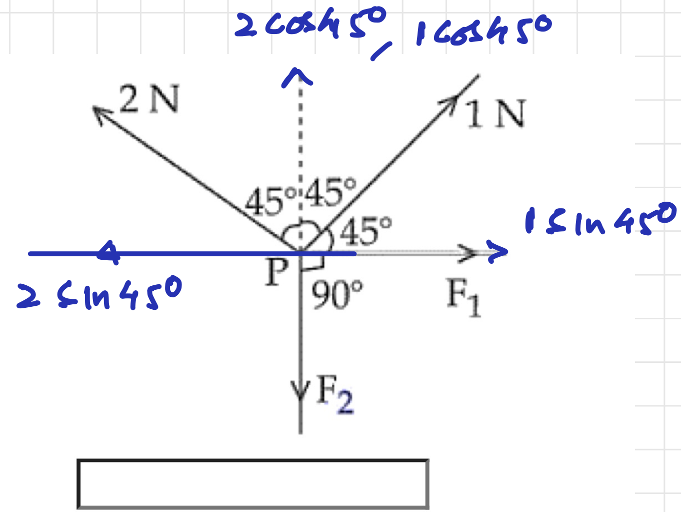
$$s \propto u^2$$

$$\frac{s_1}{s_2} = \frac{u^2}{u^2/9} = 9$$

$$s_2 = \frac{s_1}{9} = \frac{27}{9} = 3\ mt$$

Q82: Four forces are acting at a point P in equilibrium as shown in figure. The ratio of force to is 1 : x Where x = __3__.





$$2\cos 45^\circ + 1\cos 45^\circ = F_2$$

$$F_2 = 3\cos 45^\circ = \frac{3}{\sqrt{2}}\ N$$

$$2\sin 45^\circ = F_1 + 1\sin 45^\circ$$

$$F_1 = 1\sin 45^\circ = 1/\sqrt{2}\ N$$

$$\frac{F_1}{F_2} = \frac{1/\sqrt{2}}{\frac{1}{\sqrt{2}} \times 3} = \frac{1}{3} = \frac{1}{x} \Rightarrow x = 3$$

Q83: A wire of length L and radius r is clamped rigidly at one end. When the other end of the wire is pulled by a force F, its length increases by 5 cm. Another wire of the same material of length 4L and radius 4r is pulled by a force 4F under same conditions. The increase in length of this wire is __5__ cm.

$$Y = \frac{F/A}{\Delta l / l}$$

$$Y = \frac{F(l)}{\pi r^2 \Delta l}$$

$$\Delta l_1 = \frac{F(l)}{Y(\pi r^2)} = 5\text{ cm}$$

$$\Delta l_2 = \frac{4F(4l)}{\pi \times 16 r^2 Y} = 5\text{ cm}$$

Q84: A unit scale is to be prepared whose length does not change with temperature and remains 20 cm, using a bimetallic strip made of brass and iron each of different length. The length of both components would change in such a way that difference between their lengths remains constant. If length of brass is 40 cm and length of iron will be ______cm.

$\left(\alpha_{iron} = 1.2 \times 1-^{-5} K^{-1}\ and\ \alpha_{brass} = 1.8 \times 10^{-5} K^{-1}\right).$

60.00 cm

$l_t = l_0 (1 + \alpha \Delta T)$

$l_t - l_0 = l_0 (\alpha)(\Delta T)$

$\Delta l = l_0 (\alpha)(\Delta T)$

$\alpha_B l_B = \alpha_i l_i$

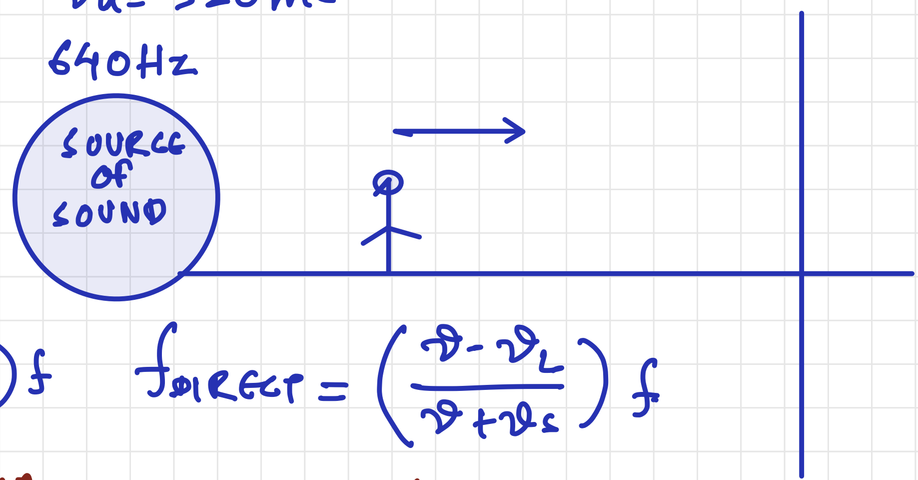
$l_i = \frac{1.8 \times 10^{-5} \times 40}{1.2 \times 10^{-5}}$

$= \frac{120}{2} = 60\ cm.$

Q85: An observer is riding on a bicycle and moving towards a hill at . He hears a sound from a source at some distance behind him directly as well as after its reflection from the hill. If the original frequency of the sound as emitted by source is 640 Hz and velocity of the sound in air is 320 m/s, the beat frequency between the two sounds heard by observer will be _20_ Hz.

$v_a = 320\,ms^{-1}$

640 Hz



$$f_{reflected} = \left(\frac{v+v_L}{v-v_s}\right)f$$

$$= \left(\frac{320+5}{320}\right)\times 640$$

$$= 650\ Hz$$

$$f_{DIRECT} = \left(\frac{v-v_L}{v+v_s}\right)f$$

$$= \left(\frac{320-5}{320}\right)\times 640 = 630\ Hz$$

$$f_{BEAT} = 650 - 630 = 20\ Hz$$

Q86: The volume charge density of a sphere of radius 6 m is . The number of lines of force per unit surface area coming out from the surface of the sphere is 4.5 $\times 10^{10}$ N/C.

.

[Given: Permittivity of vacuum]

[Given: Permittivity of vacuum $\in_0 = 8.85 \times 10^{-12} C^2 N^{-1} - m^{-2}$]

$\phi = E A$

$\frac{\phi}{A} = E$

→ number of lines of force per unit surface area = ELECTRIC FIELD

$E = \frac{1}{4\pi\epsilon_0} \frac{q}{R^2}$

$= \frac{1}{4\pi\epsilon_0} \frac{\sigma(\frac{4}{3}\pi R^3)}{R^2}$

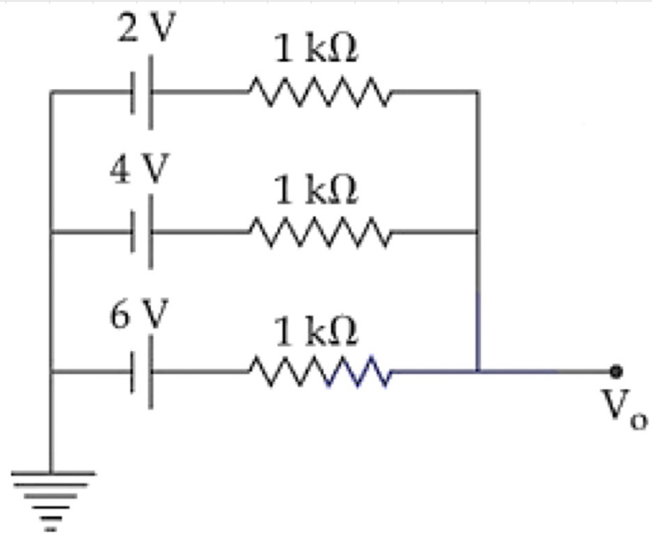
$= \frac{\sigma R}{3\epsilon_0}$

$= \frac{2 \times 6}{3 \times 8.85 \times 10^{-12}}$

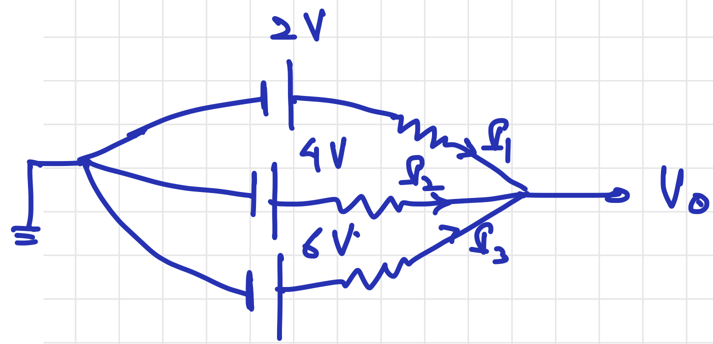
$= 0.45 \times 10^{12}$ N/C

$= 45 \times 10^{10}$ N/C

Q87: In the given figure, the value of V_0 will be ____ V.



4V



$$I_1 + I_2 + I_3 = 0$$

$$\frac{V_0 - 2}{1\,k\Omega} + \frac{V_0 - 4}{1\,k\Omega} + \frac{V_0 - 6}{1\,k\Omega} = 0$$

$$3V_0 - 12 = 0$$

$$V_0 = 4 \text{ volt}$$

Q88: Eight copper wire of length and diameter d are joined in parallel to form a single composite conductor of resistance R. If a single copper wire of length 2L have the same resistance (R) then its diameter will be ____4____ d.

$$R = \frac{\rho L (4)}{\pi d^2}$$

Eight copper wire in parallel

$$R_{eq} = \frac{R}{8} = \frac{\rho L (4)}{8 \pi d^2} = \frac{\rho L}{2 \pi d^2}$$

$$= \frac{\rho (2l)(4)}{\pi d_1^2}$$

Resistance of single wire of length 2l

$$\frac{\rho L}{2 \pi d^2} = \frac{\rho (2l)(4)}{\pi d_1^2}$$

$$d_1^2 = 16 d^2$$

$$d_1 = 4d$$

Q89: The energy band gap of semiconducting material to produce violet (wavelength) 4000 Å LED is 3.105 eV. (Round off to the nearest integer)

$$E_g = \frac{hc}{\lambda} = \frac{1242}{\lambda\,(nm)} = \frac{1242}{400}$$

$$= 3.105 \text{ eV}$$

Q90: The required height of a TV tower which can cover the population of 6.03 lakh is h. If the average population density is 100 per square km and the radius of earth is 6400 km, then the value of h will be __150__ m.

$$d = \sqrt{2Rh}$$

$$= \sqrt{2 \times 6400 \times h \times 10^{-3}}$$

$$\text{Area} = \pi d^2$$

$$= (\pi \times 2 \times 6400 \times h \times 10^{-3})\ km^2$$

$$= 6.03 \times 100000$$

$$= 100\pi \times 2 \times 6400 \times 10^{-3} h$$

$$h = \frac{6.03 \times 10^5}{10 \times \pi \times 128}$$

$$h = 150\,m$$

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ELECTRIC DISPLACEMENT, AVG KINETIC ENERGY,LOGIC GATE ,CHARGE DENSITY ARE TRICKY

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