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# JEE (Main)

PAPER-1 (B.E./B. TECH.)

2021



## COMPUTER BASED TEST (CBT)
## Memory Based Questions & Solutions

**Date: 27 August, 2021 (SHIFT-1) | TIME : (9.00 a.m. to 12.00 p.m)**

**Duration: 3 Hours | Max. Marks: 300**

**SUBJECT: PHYSICS**

**Resonance Eduventures Ltd.**
Reg. Office & Corp. Office : CG Tower, A-46 & 52, IPIA, Near City Mall, Jhalawar Road, Kota (Raj.) - 324005
Ph. No.: +91-744-2777777, 2777700 | FAX No. : +91-022-39167222
To Know more : sms RESO at 56677 | Website : www.resonance.ac.in | E-mail : contact@resonwance.ac.in | CIN : U80302RJ2007PLC024029
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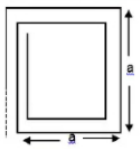
## PART : PHYSICS

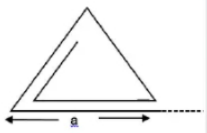
**1.** A conducting wire of length 24a is used to form two setup of coils, first in form of square of side a and second in the form of equilateral triangle of side a .Find ratio of magnetic moment of coil in two cases ?

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

**Ans.** (1)

**Sol.**




$4an_1 = 24\ a$

thus $n_1 = 6$ turns

$3an_2 = 24a \Rightarrow n_2 = 8$ turns

$$\frac{M_1}{M_2} = \frac{n_1 i A_1}{n_2 i A_2} = \frac{6 \times a^2}{8 \times a^2 \times \frac{\sqrt{3}}{4}} = \frac{\sqrt{3}}{1}$$

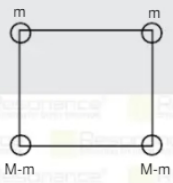
**2.** A particle of mass 2 M is divided in four particles of mass m, m, M-m and M-m. All particle are arrange on vertex of square of side a. Find ratio of M/m, for which potential energy of this system is



(1) 2 (2) 1/2 (3) 3 (4) 1/3

**Ans.** (1)

**Sol.** $U = \frac{Gm^2}{a} + \frac{G(M-m)^2}{a} + \frac{2Gm(M-m)}{a} + \frac{2Gm(M-m)}{\sqrt{2}a}$




For maxima or minima of potential energy $\frac{dU}{dm}=0$

$\frac{dU}{dm}=\frac{G}{a}(2m-2(M-m)+(M-2m)2+\sqrt{2}(M-2m)$

$(4m-4m-2\sqrt{2}m)+(-2M+2M+\sqrt{2}M)=0\ ;\ \sqrt{2}M=2\sqrt{2}m\ ;\ \frac{M}{m}=2$







**3.** A source A produce frequency of horn 1120 Hz. Source and observer are moving towards each other with speed 36 km/hr and 72 km/hr respectively. Find frequency of horn observed by observer (speed of sound V = 330 m/s)

(1) 1210Hz (2) 1200 Hz (3) 1225Hz (4) 1250Hz

**Ans.** **(3)**

**Sol.** A ●⟶ ⟵● B

$V_S$ = 36 km/hr = 10 m/s $V_0$ = 72 km/hr = 20 m/s

$f'=f_0\left(\frac{V+V_0}{V-V_S}\right)$

$f'=1120\left(\frac{330+20}{330-10}\right)=1120\times\frac{35}{32}=1225Hz$

**4.** For an ideal gas $PT^3$ = constant. Find coefficient of volume expansion :

(1) 1/T (2) 2/T (3) 3/T (4) 4/T

**Ans.** **(4)**

**Sol.** $\gamma=\frac{1}{V}\frac{dV}{dT}$



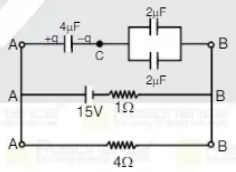
$\frac{1}{V}T^3$ = Constant

$T^4V^{-1}=C$

$V^{-1}(4T^3dT)+T^4\left(\frac{-1}{V^2}dV\right)=0$

$\frac{dV}{dT}=\frac{4T^3/V}{T^4/V^2}=\frac{4V}{T}\qquad\therefore\ \gamma=\frac{4}{T}$

**5.** Find q on 4μf capacity at t = ∞




(1) 8μC (2) 12μC (3) 20μC (4) 24μC

**Ans.** **(4)**

**Sol.** Using $i=\frac{15}{4+1}=3A$

$\therefore V_{AB}=i\times4=12\ V\qquad\therefore V_{AC}=V_{CB}=6$ Volt

$\therefore$ q on 4μF = $CV_{AC}=24\mu C$







**6.** n identical resistance each having value 10 Ω are connected in series with battery of emf 20V & internal resistance 10Ω. Current in circuit is $i_s$. If they are connected in parallel to same source current is $i_p$. If $i_p=20i_s$ then n will be :

(1) 10 (2) 8 (3) 12 (4) 20

**Ans.** (4)

**Sol.** $i_p = 20i_s$

$$\frac{20}{\left(\frac{10}{n}+10\right)} = 20\left(\frac{20}{10n+10}\right)$$

$$\frac{20n}{10+10n} = 20\left(\frac{20}{10n+10}\right)$$



**7.** Height of transmission and receiver tower are 380m and 800 m respectively. If radius of earth is 6400km then find range of LOS communication.

(1) 150 km (2) 171 km (3) 250 km (4) 200 km

**Ans.** **(2)**

**Sol.** Range $= \sqrt{2Rh_1} + \sqrt{2Rh_2} = \sqrt{2\times6400\times380} + \sqrt{2\times6400\times800} \approx 171$ km

**8.** An electromagnetic wave is given by $E = \sin\left(50x + 10^{10}t\right)\frac{V}{m}$. Find speed in terms of C.

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

**Ans.** **(1)**

**Sol.** $\omega = 10^{10}$

$k = 50$

$$\text{Speed} = \frac{\omega}{k} = \frac{10^{10}}{50} = 2\times10^8 = \frac{2}{3}C$$

**9.** If E is electric field intensity & H is the magnetic intensity then find SI unit of E/H :

(1) Joule/(second-Ampere$^2$) (2) Ampere/(second$^2$)

(3) Joule/Ampere$^2$ (4) Ampere/metre

**Ans.** **(1)**

**Sol.** $\frac{E}{H} = \frac{\frac{F}{q}}{\frac{I}{t}} = \frac{Fr}{I^2t}$ = Joule/(second-Ampere$^2$)



(1) $\mu_r$ (2) $\mu_0$ (3) power factor (4) Quality factor

**Ans.** **(2)**





**11.** When $F_1$ force is applied at an angle 45º w.r.t. direction of displacement, work done by force in this case is equal to work done when a force $F_2$ is applied on same block at an angle 60º w.r.t. direction of displacement. If displacement in both the cases is same, the ratio of $\frac{F_1}{F_2}$ is $\frac{1}{\sqrt{x}}$, find x?

**Ans.** 2

**Sol.** $w_1 = w_2$



$$\frac{F_1}{F_2} = \frac{1}{\sqrt{2}}$$

$x = 2$

**12.** A disc having uniform surface charge density $\sigma$ is placed in y-z plane with center at origin and radius R. Find electric field at a point (x, 0, 0).

(1) $E_x = \frac{\sigma}{2\epsilon_0}\left[1 - \frac{x}{\sqrt{R^2+x^2}}\right]$ (2) $E_x = \frac{\sigma}{\epsilon_0}\left[1 - \frac{x}{\sqrt{R^2+x^2}}\right]$

(3) $E_x = \frac{\sigma}{\epsilon_0}\left[1 - \frac{\sqrt{R^2+x^2}}{x}\right]$ (4) $E_x = \frac{\sigma}{2\epsilon_0}\left[x - \frac{x}{\sqrt{R^2+x^2}}\right]$

**Ans.** **(1)**

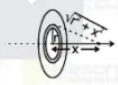
**Sol.** The disc can be considered to be a collection of large number of concentric rings. Consider an element of the shape of rings of radius r and of width dr. Electric field due to this ring at P is


$$dE = \frac{K.\sigma 2\pi r\,dr.x}{(r^2+x^2)^{3/2}}$$

Put, $r^2 + x^2 = y^2$

$2rdr = 2ydy$

$$\therefore \quad dE = \frac{K.\sigma 2\pi y.dy.x}{y^3} = 2K\sigma\pi.x\,\frac{ydy}{y^3}$$



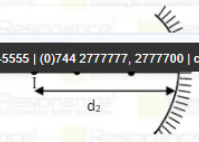
$$\therefore \quad E = \int dE \Rightarrow E = 2K\sigma\pi x \int_x^{\infty} \frac{1}{y^2} dy = 2K\rho\pi x. \left[-\frac{1}{y}\right]_x^{\infty}$$

$$= 2K\sigma\pi x \left[+\frac{1}{x} - \frac{1}{\sqrt{R^2+x^2}}\right] = 2K\sigma\pi \left[1 - \frac{x}{\sqrt{R^2+x^2}}\right] = \frac{\sigma}{2\varepsilon_0}\left[1 - \frac{x}{\sqrt{R^2+x^2}}\right] \text{ along the axis}$$





**13.** Find the radius of curvature of concave mirror. If object is at $d_1$ distance away from Pole and image formed is at $d_2$ distance away from Pole :




(1) $\frac{2d_1d_2}{d_1+d_2}$ (2) $\frac{d_1d_2}{d_1+d_2}$ (3) $\frac{d_1d_2}{2d_1+d_2}$ (4) $\frac{d_1d_2}{d_1+2d_2}$

**Ans.** (1)

**Sol.** $xy = f^2$

$(d_1 - f)(d_2 - f) = f^2$

$f = \frac{d_1d_2}{d_1+d_2}$

$Roc = 2f = \frac{2d_1d_2}{d_1+d_2}$

**14.** Find moment of inertia of a uniform square plate of mass M and side length '$\ell$' about an axis passing through one of its vertex and perpendicular to plane ?

(1) $\frac{M\ell^2}{3}$ (2) $\frac{2M\ell^2}{3}$ (3) $\frac{M\ell^2}{6}$ (4) $\frac{M\ell^2}{12}$

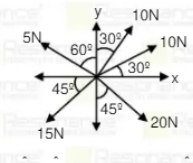
**Ans.** (2)

**Sol.**


$$I_Z = I_{cm} + M\left(\frac{\ell}{\sqrt{2}}\right)^2$$

$$= \frac{M\ell^2}{6} + \frac{M\ell^2}{2} = \frac{4M\ell^2}{6} = \frac{2M\ell^2}{3}$$






(1) $-10{\cdot}75\hat{i} - 8\hat{j}$ (2) $-10{\cdot}75\hat{i} - 9\hat{j}$ (3) $-12{\cdot}75\hat{i} - 7\hat{j}$ (4) $-15{\cdot}75\hat{i} - 9\hat{j}$

**Ans.** (4)

**Sol.** Resultant $(\vec{R}) = \hat{i}\,(10\cos 30^\circ + 10\cos 60^\circ - 5\cos 30^\circ - 15\cos 45^\circ + 20\cos 45^\circ)$

$+\ \hat{j}\,(10\sin 30^\circ + 10\sin 60^\circ + 5\sin 30^\circ - 15\sin 45^\circ - 20\cos 45^\circ)$

$= -15.75\,\hat{i} - 9\,\hat{j}$

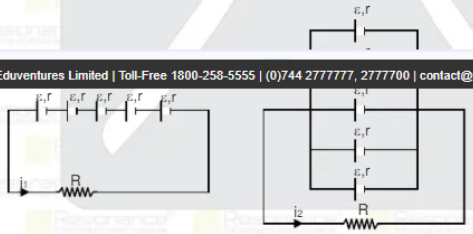
**16.** 5 same cells (5V, 1Ω) connected in series and then in Parallel with an external resistance R respectively if current in both circuits is equal then find the value of R.

(1) 4Ω (2) 3Ω (3) 2Ω (4) 1Ω

**Ans.** **(4)**

**Sol.**






$i_1 = \dfrac{5\varepsilon}{R+5r}$ $\qquad$ $i_2 = \dfrac{\varepsilon}{R+\dfrac{r}{5}}$

$i_1 = i_2$

$\dfrac{5\varepsilon}{R+5r} = \dfrac{\varepsilon}{R+\dfrac{r}{5}} \Rightarrow \qquad R = r = 1\Omega$







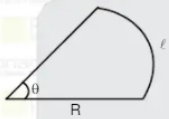
**17.** A huge circular arc of length 4.4 ly subtends an angle '4S' at the centre of the circle. How long it would take for a body to complete 4 revolution if its speed is 8 Au per second ?

**Given :** 1 ly = $9.46 \times 10^{15}$ m ; 1 Au = $1.5 \times 10^{11}$ m

(1) $3.5 \times 10^6$ S (2) $4.5 \times 10^6$ S (3) $7.2 \times 10^8$ S (4) $4.1 \times 10^8$ S

**Ans.** **(2)**

**Sol.**




$\ell = 4.4\text{ ly} = 4.4 \times 9.46 \times 10^{15}$

length of Arc.$= \ell = R\theta$

$4.4 \times 9.46 \times 10^{15} = R\theta$

$\theta = 4S = 4 \times 4.843 \times 10^{-6} = 1.94 \times 10^{-5}$ rad

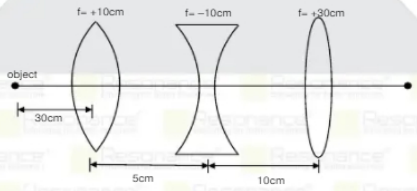
$4.4 \times 9.46 \times 10^{15} = R \times 1.94 \times 10^{-5}$



4 revolution means distance = $4 \times 2\pi R$ metre

time $= \dfrac{\text{distance}}{\text{speed}} = \dfrac{4\times 2\pi R}{12\times 10^{11}}$ ; time $= \dfrac{8\times 3.14\times 2.1455\times 10^{21}}{12\times 10^{11}} \Rightarrow 4.5 \times 10^{10}$ sec

**18.** For the given arrangement, what will be the distance of final image from third lens?




(1) 75 (2) 30 (3) ∞ (4) 40

**Ans.** **(2)**

**Sol.** (1) Lens formula

$\frac{1}{v}-\frac{1}{u}=\frac{1}{f}$,

$\frac{1}{v}-\frac{1}{-30}=\frac{1}{10}$

$\frac{1}{v}=\frac{1}{10}-\frac{1}{30}$; $\frac{1}{v}=\frac{3-1}{30}$; v = 15 cm

(2) u = +10

$\frac{1}{v}-\frac{1}{10}=\frac{1}{-10}$

$\frac{1}{v}=\frac{-1}{10}+\frac{1}{10}$ $v = \infty$

(3) V = + 30 cm (from third lens)

**19.** Common Emitter transistor is used in which region as an amplifier.

(1) Active region (2) Saturation region (3) Cut off region (4) Cut and saturation



**20.** Initial number of active nuclei in a radioactive element is $10^{10}$. If half-life of radioactive element is 1 min. What will be the number of active nuclei after 30 sec? [$e^{-0.35} = 0.70$]

(1) $0.7 \times 10^8$ (2) $0.7 \times 10^{10}$ (3) $0.7 \times 10^6$ (4) $0.7 \times 10^9$

**Ans.** **(2)**

**Sol.** $N = N_0\, e^{\frac{-\ell n2.t}{t_{1/2}}}$

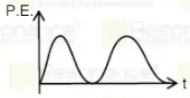
$= 10^{10}e^{-0.35} = 0.7 \times 10^{10}$

**21.** For given displacement-time curve of SHM. The potential-energy vs time curve will be ?


(1) 


(2) 


(3) 


(4) 


**Ans.** (4)


Resonance Eduventures Ltd.
Reg. Office & Corp. Office : CG Tower, A-46 & 52, IPIA, Near City Mall, Jhalawar Road, Kota (Raj.) - 324005
Ph. No.: +91-744-2777777, 2777700 | FAX No. : +91-022-39167222
To Know more : sms RESO at 56677 | Website : www.resonance.ac.in | E-mail : contact@resonance.ac.in | CIN : U80302RJ2007PLC024029
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**Sol.** Considering → Spring – mass system

$x = x_0 \sin \omega t$

$P.E. = \frac{1}{2}kx^2 = \frac{1}{2}kx_0^2 \sin^2\omega t = c \sin^2\omega t$

$\Rightarrow \quad PE = \left(\frac{1-\cos 2\omega t}{2}\right)$

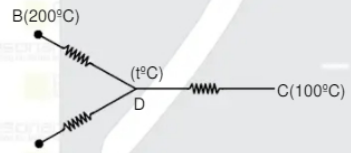
**22.** Two identical rods are arranged as shown in figure. D is the midpoint of rod BC. Find the heat transfer rate through rods AD. $\left(\text{given } \frac{L}{KA} = 10kw^{-1}\right)$



A 125°C

**Ans.** 2

**Sol.**




$Q_{BD} + Q_{AD} = Q_{DC}$

$$\frac{KA(200-t)}{\frac{\ell}{2}} + \frac{KA(125-t)}{\ell} = \frac{(t-100)KA}{\frac{\ell}{2}}$$

$400 - 2t + 125 - t = 2t - 200$

$725 = 5t$

$t = 145°C$



$$Q_{AD} = \frac{KA(125-145)}{\ell} = \left|-\frac{20}{\frac{\ell}{KA}}\right| = \left|-\frac{20}{10}W\right| = 2W$$





**23.** In millikan's oil drop experiment what will be the terminal velocity of an uncharged drop of radius $2.0 \times 10^{5}$ m and density of oil is $1.2 \times 10^{3}$ kg $m^{-3}$. Take viscosity of liquid = $1.8 \times 10^{-5}$ N $5m^{-1}$ : (Neglect buoyance force due to air)

(1) $5.9 \times 10^{-2}$ m/s (2) $4.9 \times 10^{-2}$ m/s (3) $3.9 \times 10^{-2}$ m/s (4) $2.9 \times 10^{-2}$ m/s

**Ans.** **(1)**

**Sol.** viscous force = weight

$6\pi\eta r v_T = mg$

$\frac{4}{3}\pi r^3 \rho g$

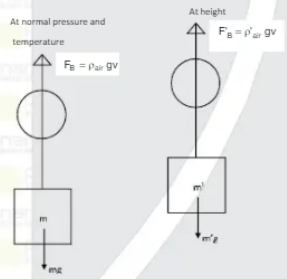


**24.** A balloon carries a total load of 185 kg at normal pressure and temperature of 27° C. What load with the balloon carry on rising to a height at which the barometer pressure is 45 cm of Hg and the temperature is –7°C .Assuming the volume constant :

(1) 123.54 kg (2) 219.07 kg (3) 214.15 kg (4) 181.46 kg

**Ans.** **(1)**

**Sol.**




$\rho_{air}\, gv = mg$ $\qquad$ $\rho_{air}\, gv = m'g$

$\rho_{air}\, v = 185$ kg $\qquad$ $\rho_{air}\left(\frac{P'}{P} \times \frac{T}{T'}\right)V = m'$

$$185\left[\frac{45}{76} \times \frac{300}{266}\right] = m'$$



**25.** in a photoelectric effect, if intensity of light is increased then

(1) Frequency increases (2) Number of photon increases

(3) Kinetic energy of photoelectron increases (4) Momentum of photon increases

**Ans.** **(2)**

**Sol.** $N = \frac{IA}{h\nu}$

**26.** In a circuit, current is given as $i=\sqrt{42}\sin\left(\frac{4t}{T}\right)+10$. Find rms current in circuit?



**Ans.** (2)

**Sol.** $i^2 = 42\sin^2\left(\frac{4t}{T}\right)+100+2\sqrt{42}\sin\left(\frac{4t}{T}\right)$

$\langle i^2\rangle = \frac{42}{2}+100$ ; $i_{rms}=\sqrt{\langle i^2\rangle}=\sqrt{121}=11$

**27.** If velocity of a particle is given by $v=\sqrt{5000+24x}$. Where x is displacement. The acceleration of particle is :

(1) 12 m/s² (2) 15 m/s² (3) 18 m/s² (4) 21 m/s²

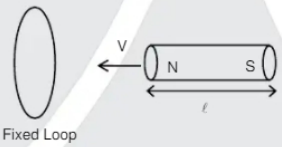
**Ans.** (1)

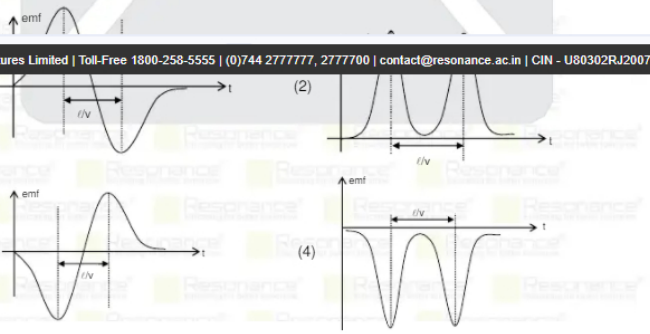
**Sol.** $a=\frac{vdv}{dx}$

$v=\sqrt{5000+24x}\times\frac{1}{2\sqrt{5000+24x}}\times 24$

$a = 12$ m/s²

**28.** A Bar magnet moving with velocity 'V' towards a fixed conducting circular loop find the graph of emf V/S t. consider anticlockwise emf as positive emf where observer is right of south pole of magnet





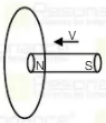

**Ans.** (1)



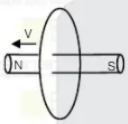




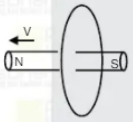
**Sol.** As Magnet is approaching toward the loop magnetic flux increases and Rate of increment of flux also increases so emf increases with time



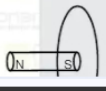

at this moment emf is maximum



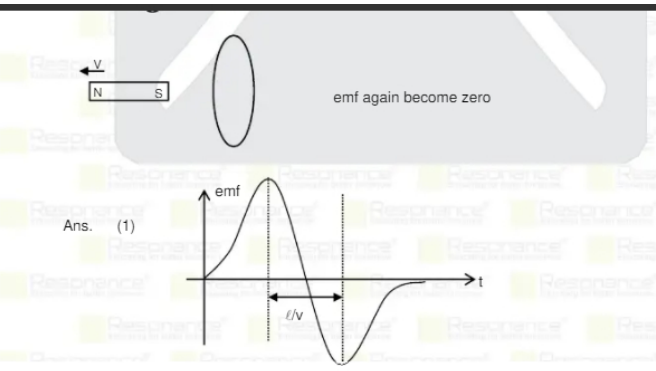

Magnet is in middle of coil, at this moment emf is equal to zero




Now again flux start changing however polarity of emf get reverse



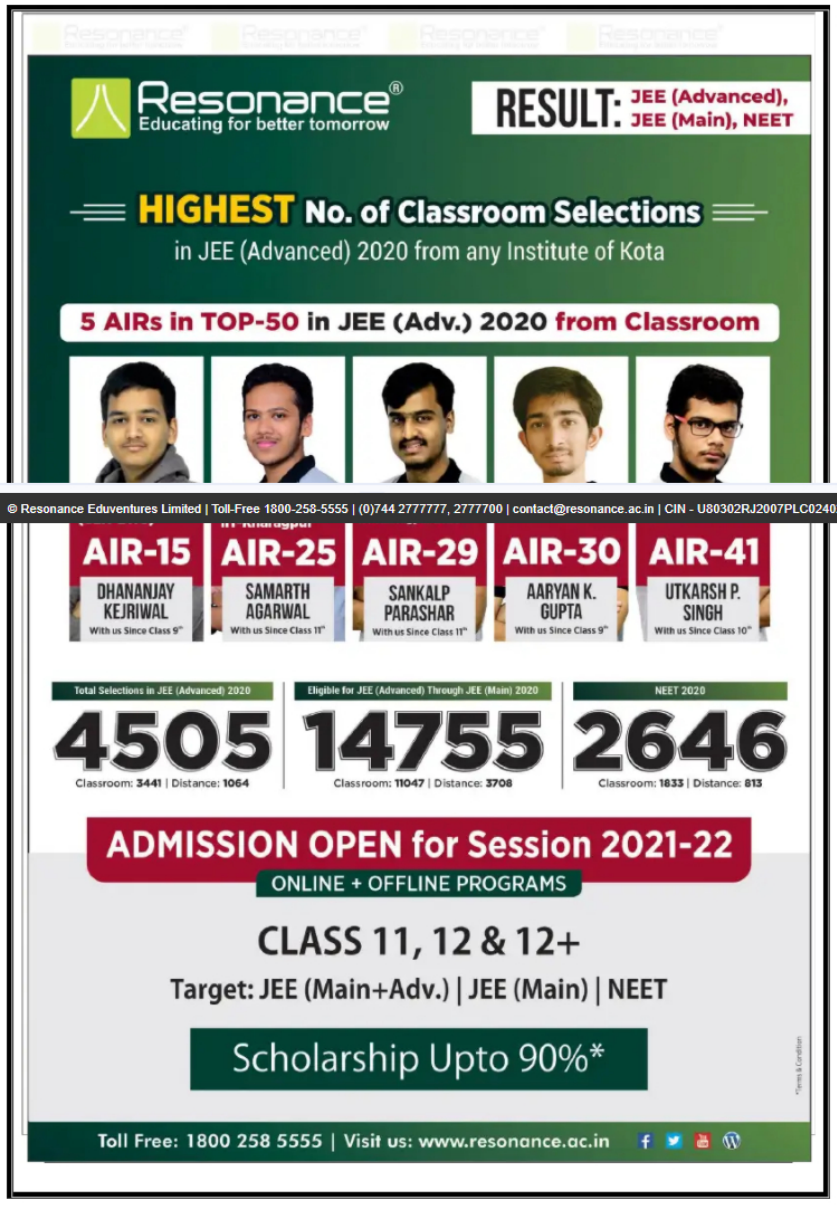

At this moment emf is again maximum




Ans. (1)





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