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

JEE (Main) 2020

COMPUTER BASED TEST (CBT)

Questions & Solutions

Date: 04 September, 2020 (SHIFT-2) | TIME : (03.00 p.m. to 06.00 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@resonance.ac.in | **CIN : U80302RJ2007PLC024029**

Toll Free : 1800 258 5555 7340010333 facebook.com/ResonanceEdu twitter.com/ResonanceEdu www.youtube.com/resowatch blog.resonance.ac.in

PART : PHYSICS

Single Choice Type (एकल विकल्पीय प्रकार)

This section contains **20 Single choice questions.** Each question has 4 choices (1), (2), (3) and (4) for its answer, out of which **Only One** is correct.

इस खण्ड में **20 एकल विकल्पी प्रश्न** हैं। प्रत्येक प्रश्न के 4 विकल्प (1), (2), (3) तथा (4) हैं, जिनमें से **सिर्फ एक सही** है।

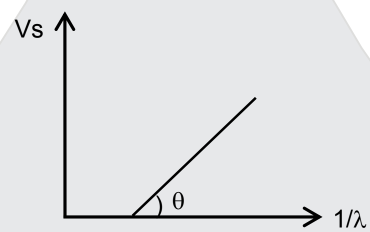
1. A body is moving in a low circular or it about a planet of mass M and radius R. The radius of the orbit can be taken to be R itself. Then the ratio of the speed of this body in the orbit to the escape velocity from the planet is :

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

Ans. **(2)**

Sol. $$\frac{v_0}{v_e} = \frac{\sqrt{\frac{Gm}{r}}}{\sqrt{\frac{2Gm}{r}}} = \frac{1}{\sqrt{2}}$$

2. In a photoelectric effect experiment, the graph of stopping potential V versus reciprocal of wavelength obtained is shown in the figure. As the intensity of incident radiation is increased :



(1) Slope of the straight line get more steep
(2) Graph does not change
(3) Straight line shifts to right
(4) Straight line shifts to left

Ans. **(2)**

Sol. $eV_S = h\nu - w$

$$V_S = \frac{h\nu}{e} - \frac{w}{e}$$

Frequency and work function are constant therefore graph does not change.

3. A small ball of mass m is thrown upward with velocity u from the ground. The ball experiences a resistive force mkv^2 where v is it speed. The maximum height attained by the ball is :

(1) $\frac{1}{2k}\tan^{-1}\frac{ku^2}{g}$ (2) $\frac{1}{k}\ell n\left(1+\frac{ku^2}{2g}\right)$ (3) $\frac{1}{k}\tan^{-1}\frac{ku^2}{2g}$ (4) $\frac{1}{2k}\ell n\left(1+\frac{ku^2}{g}\right)$

Ans. **(4)**

Sol. $F_{net} = ma$

$$-mg - mkv^2 = mv\frac{dv}{ds}$$

$$v\frac{dv}{ds} = -g - kv^2$$

$$-\int_{v_0}^{0}\frac{vdv}{g+kv^2} = \int_{0}^{h_{max}} ds = h_{max}$$

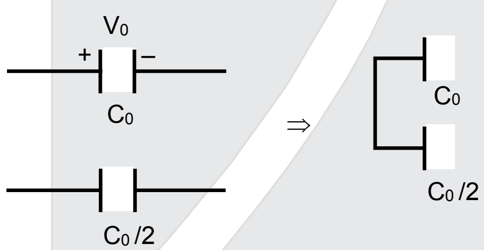
$$h_{max} = \frac{1}{2K}\ell n\left(\frac{g+kv_0^2}{g}\right)$$

4. A capacitor C is fully charged with voltage V_0. After disconnecting the voltage source, it is connected in parallel with another uncharged capacitor of capacitance C/2. The energy loss in the process after the charge is distributed between the two capacitors is :

(1) $\frac{1}{6}CV_0^2$ (2) $\frac{1}{2}CV_0^2$ (3) $\frac{1}{4}CV_0^2$ (4) $\frac{1}{3}CV_0^2$

Ans. **Correction answer is (1) but IIT gives (3)**

Sol.



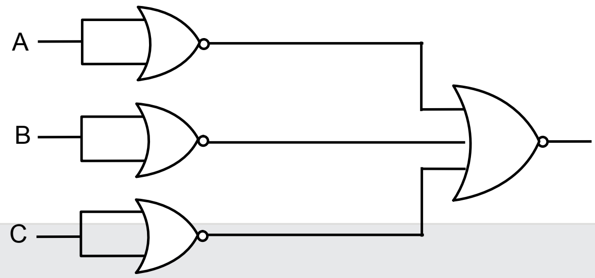
heat loss

$$H = \frac{C_1C_2}{2(C_1+C_2)}(V_1 - V_2)^2$$

$$= \frac{C\times\frac{C}{2}}{2\left(C+\frac{C}{2}\right)}(V_0-0)^2 = \frac{C}{6}V_0^2$$

$$H = \frac{1}{6}C_0V_0^2$$

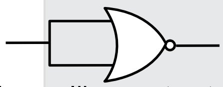
5. Identify the operation performed by the circuit given below :



(1) NOT (2) AND (3) NAND (4) OR

Ans. **(2)**

Sol.



Behaves like a not gate so boolen equation will be

$y = \overline{\overline{A} + \overline{B} + \overline{C}}$

$y = A . B . C$

whole arrangement behaves like a AND gate

6. The electric field of a plane electromagnetic wave is given by $\vec{E} = E_0(\hat{x} + \hat{y})\sin(kz - \omega t)$. Its magnetic field will be given by

(1) $\frac{E_0}{c}(\hat{x} + \hat{y})\sin(kz - \omega t)$ (2) $\frac{E_0}{c}(\hat{x} - \hat{y})\sin(kz - \omega t)$

(3) $\frac{E_0}{c}(\hat{x} - \hat{y})\cos(kz - \omega t)$ (4) $\frac{E_0}{c}(-\hat{x} + \hat{y})\sin(kz - \omega t)$

Ans. **(4)**

Sol. $\vec{E} \times \vec{B} \,||\, \vec{C}$

7. The driver of bus approaching a big wall notices that the frequency of his bus's horn changes from 420 Hz to 490 Hz when he hears it after it gets reflected from the wall. Find the speed of the bus if speed of the sound is 330 ms^{-1} :

(1) 81 kmh^{-1} (2) 71 kmh^{-1} (3) 61 kmh^{-1} (4) 91 kmh^{-1}

Ans. **(4)**

Sol. Frequency appeared at wall

$f_w = \frac{330}{330 - v}.f$ …(1)

$f' = \frac{330 + v}{330}.f_w = \frac{330 + v}{330 - v}.f$

$490 = \frac{330 + v}{330 - v}.420$

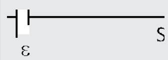
$v = \frac{330 \times 7}{91} \approx 25.38$ m/s = 91 Km/s

8. A series L-R circuit is connected to a battery of emf V. If the circuit is switched on at t = 0, then the time at which the energy stored in the inductor reaches (1/n) times of its maximum value, is :

(1) $\frac{L}{R}\ell n\left(\frac{\sqrt{n}}{\sqrt{n}-1}\right)$ (2) $\frac{L}{R}\ell n\left(\frac{\sqrt{n}-1}{\sqrt{n}}\right)$ (3) $\frac{L}{R}\ell n\left(\frac{\sqrt{n}}{\sqrt{n}+1}\right)$ (4) $\frac{L}{R}\ell n\left(\frac{\sqrt{n}+1}{\sqrt{n}-1}\right)$

Ans. **(1)**

Sol.



Potential energy stored in inductor is given by U = $\frac{1}{2}LI^2$

$U \propto I^2$

$\frac{U}{U_0} = \left(\frac{I}{I_0}\right)^2$

$\frac{1}{n} = \left(\frac{I}{I_0}\right)^2$

$\frac{I}{I_0} = 1 - e^{-RT/L} = \frac{1}{\sqrt{n}}$

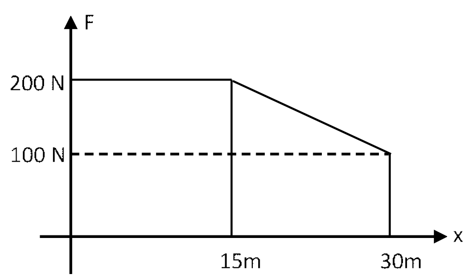
t = $\frac{L}{R}\ln\frac{\sqrt{n}}{\sqrt{n}-1}$

9. A person pushes a box on a rough horizontal plateform surface. He applies a force of 200 N over a distance of 15m. Thereafter, he gets progressively tired and his applied force reduces linearly with distance to 100 N. The total distance through which the box has been moved is 30 m. What is the work done by the person during the total movement of the box?

(1) 5250 J (2) 3280 J (3) 2780 J (4) 5690 J

Ans. **(1)**

Sol.



W = area = (200 × 15) + $\frac{1}{2}(100+200)$ × 15

= 3000 + 2250

W = 5250 J

10. Match the thermodynamics processes taking place in a system with the correct conditions. In the table : DQ is the heat supplied, DW is the work done and DU is change in internal energy of the system.

Match the following

(I)	Adiabatic	(A) $\Delta W = 0$
(II)	Isothermal	(B) $\Delta Q = 0$
(III)	Isobaric	(C) $\Delta U \neq 0, \Delta W \neq 0$, $\Delta Q \neq 0$
(IV)	Isochoric	(D) $\Delta U = 0$

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

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

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

(4) $I \to B$ $II \to A$ $III \to D$ $IV \to Cs$

Ans. **(2)**

Sol. In Adiabatic $\Delta Q = 0$

In Isothermal $\Delta U = 0$

In Isochoric $\Delta W \neq 0$

11. Consider two uniform discs of the same thickness and different radii $R_1 = R$ and $R_2 = \alpha R$ made of the same material. If the ratio of their moments of inertia I_1 and I_2, respectively, about their axes is $I_1 : I_2 = 1 : 16$ then the value of α is :

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

Ans. **(1)**

Sol. Moment of inertia of disc is given by $I = \frac{MR^2}{2} = \frac{[\rho(\pi R^2)t]\, R^2}{2}$

$$I \propto R^4$$

$$\frac{I_2}{I_1} = \left(\frac{R_2}{R_1}\right)^4$$

$$\frac{16}{1} = \alpha^4$$

$$\alpha = 2$$

12. A quantity x is given by ($1Fv^2/WL^4$) in terms of moment of inertia I, force F, velocity v, work W and length L. The dimensional formula for x is same as that of :

(1) force constant (2) energy density

(3) Planck's constant (4) coefficient of viscosity

Ans. **(2)**

Sol. $\frac{I\,F\,v^2}{W\ L^4} = \frac{(M^1L^2)(M^1L^1T^{-2})(L^1T^{-2})^2}{(M^1L^2T^{-2})(L^4)} = \frac{M^1L^{-2}T^{-2}}{L^3} = M^1L^{-1}T^{-2}$ = Energy density

13. A circular coil has moment of inertia 0.8 kg m^2 around any diameter and is carrying current to produce a magnetic moment of 20 am^2. The coil is kept initially in a vertical position and it can rotate freely around a horizontal diameter. When a uniform magnetic field of 4T is applied along the vertical, it starts rotating around its horizontal diameter. The angular speed the coil acquires after rotating by 60° will be :

(1) 20 rad s^{-1} (2) 10 rad s^{-1} (3) 20π rad s^{-1} (4) 10π rad s^{-1}

Ans. **(2)**

Sol. From energy conservation

$$\frac{1}{2}I\omega^2 = U_{in} - U_f$$

$$= -MB\cos60^\circ - (-MB)$$

$$\frac{MB}{2} = \frac{1}{2}I\omega^2$$

$$\frac{20\times4}{2} = \frac{1}{2}(0.8)\omega^2$$

$100 = \omega^2$

$\omega = 10$ rad

14. A paramagnetic sample shows a net magnetisation of 6A/m when it is placed in an external magnetic field of 0.4 T at a temperature of 4K. When the sample is placed in an external magnetic field of 0.3T at a temperature of 24K, then the magnetisation will be :

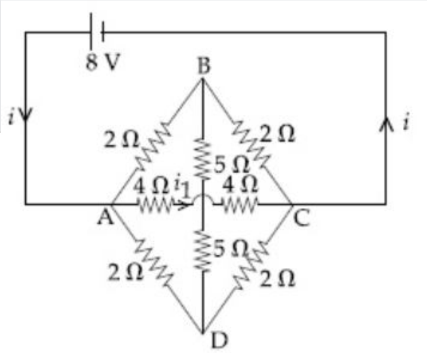
(1) 4 A/m (2) 0.75 A/m (3) 2.25 A/m (4) 1 A/m

Ans. **(2)**

Sol. $M = \frac{CB_{ext}}{T}$

Putting the value we get N = 0.25 A/m

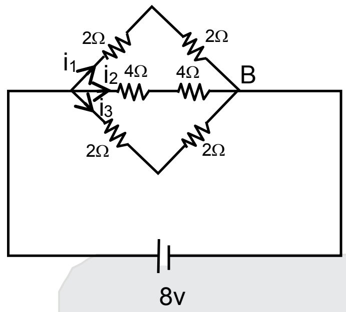
15. The value of current i_1 flowing from A to C in the circuit diagram is :



(1) 5A (2) 0.75 A/m (3) 2.25 A/m (4) 1 A/m

Ans. **(2)**

Sol.



$i_2 = \frac{8}{4+4} = 1\text{ Amp}$

16. A particle of charge q and mass m is subjected to an electric field $E = E_0(1 - ax^2)$ in the x–direction, where a and E_0 are constants. Initially the particle was at rest at x = 0. Other than the initial position the kinetic energy of the particle becomes zero when the distance of the particle from the origin is :

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

Ans. **(3)**

Sol. $W_{ex} = \Delta K$ $K_f - K_i = 0$

$$\int_0^x qEdx = 0$$

$$q\int_0^x E_0(1 - Qx^2)dx = 0$$

$$qE_0\int_0^x (1 - ax^2)dx = 0$$

$$x - \frac{ax^3}{3} = 0$$

$$1 - \frac{ax^2}{3} = 0$$

$$\frac{ax^2}{3} = 1$$

$$x^2 = \frac{3}{a}$$

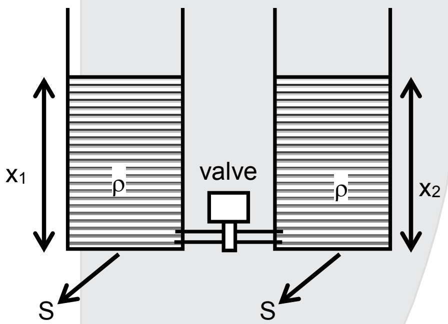
$$x = \sqrt{\frac{3}{a}}$$

17. Two identical cylindrical vessels are kept on the ground and each contain the same liquid of density d. The area of the base of both vessels is S but the height of liquid in one vessel is x_1 and in the other, x_2. When both cylinders are connected through a pipe of negligible volume very close to the bottom, the liquid flows from one vessel to the other until it comes to equilibrium at a new height. The change in energy of the system in the process is :

(1) $\frac{3}{4}gdS(x_2-x_1)^2$ (2) $\frac{1}{4}gdS(x_2-x_1)^2$ (3) $gdS(x_2+x_1)^2$ (4) $gdS(x_2^2+x_1^2)^2$

Ans. (2)

Sol.



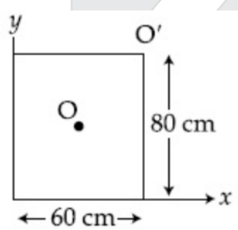
Initial height of liquid in container's of same cross section are x_1 and x_2 respectively. Now value is opened find loss in potential energy when water level be become same

loss in PE = $U_i - U_f$

$$= \left[\rho(A)x_1\frac{x_1}{2}+\rho Ax_2\frac{x_2}{2}\right]g - \left[\rho A\left(\frac{x_1+x_2}{2}\right)\times\left(\frac{x_1+x_2}{4}\right)\times 2\right]g$$

$$= \rho Ag\left[\frac{x_1^2}{2}+\frac{x_2^2}{2}-\frac{(x_1+x_1)^2}{4}\right] = \frac{\rho Ag(x_1-x_2)^2}{4}$$

18.



For a uniform rectangular sheet shown in the figure, the ratio of moments of inertia about the axes perpendicular to the sheet and passing through O (the centre of mass) and O' (corner point) is:

(1) 1/2 (2) 1/4 (3) 2/3 (4) 1/8

Ans. (2)

Sol. $$\frac{I_O}{I_{O'}} = \frac{\frac{M}{12}(a^2+b^2)}{\frac{M}{12}(a^2+b^2)+M\left(\frac{a^2}{4}+\frac{b^2}{4}\right)} = \frac{\frac{M}{12}(a^2+b^2)}{\frac{M}{3}(a^2+b^2)} = \frac{1}{4}$$

19. A cube of metal is subjected to a hydrostatic pressure 4GPa. The percentage change in the length of the side of the cube is close to : (Given bulk modulus of metal, B = 8×10^{10} Pa)

(1) 1.67 (2) 5 (3) 20 (4) 0.6

Ans. **(1)**

Sol. $\Delta P = (B)\frac{\Delta V}{V} = B \times 3\frac{\Delta L}{L}$

Putting the value of ΔP and B we get $\frac{\Delta L}{L} \times 100 = 1.67$

20. Find the Binding energy per nucleon for ${}^{120}_{50}Sn$. Mass of proton m_p = 1.00783 U, mass of neutron m_n = 1.00867 U and mass of tin nucleus m_{sn} = 119.902199 U. (take 1U = 931 MeV)

(1) 9.0 MeV (2) 8.5 MeV (3) 8.0 MeV (4) 7.5 MeV

Ans. **(2)**

Sol. Binding energy = $(\Delta M)\, C^2 = (\Delta M)\, 931$

put the value of ΔM

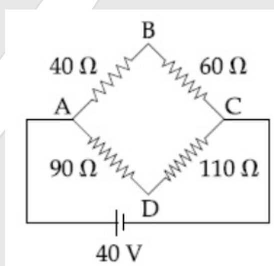
BE = 8.5 MeV

Numerical Value Type (संख्यात्मक प्रकार)

This section contains **5 Numerical value type questions.**

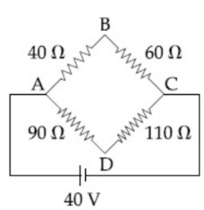
इस खण्ड में **5 सख्यात्मक प्रकार के प्रश्न** हैं।

21. Four resistance 40Ω, 60Ω, 90Ω, and 110Ω make the arms of a quadrilateral ABCD. Across AC is a battery of emf 40V and internal resistance negligible. The potential difference across BD in V is ……



Ans. 2

Sol.



From KVL

$V_B - 60\left(\frac{40}{100}\right) + 110\left(\frac{40}{200}\right) = V_D$

$V_B - V_D = 2$

22. The distance between an object and a screen is 100 cm. A lens can produce real image of the object on the screen for two different positions between the screen and the object. The distance between these two positions is 40 cm. If the power of the lens is close to $\left(\frac{N}{100}\right)$D where N is an integer, the value of N is ……….

Ans. **476.19**

Note : **NTA Answer is 5.**

Sol. $f = \frac{D^2 - d^2}{4D} = \frac{100^2 - 40^2}{4(100)} = \frac{(100+40)(100-40)}{4(100)}$ = 21 cm

$P = \frac{1}{f} = \frac{100}{21} = \frac{N}{100}$

N = 476.19.

23. The change in the magnitude of the volume of an ideal gas when a small additional pressure ΔP is applied at a constant temperature, is the same as the change when the temperature is reduced by a small quantity ΔT at constant pressure. The initial temperature and pressure of the gas were 300 K and 2 atm. respectively. If $|\Delta T| = C|\Delta P|$ then value of C in (K/atm) is ….

Ans. **150**

Sol. PV = nRT

$P\Delta V + V\Delta P = 0$

$\Delta V = -\frac{\Delta P}{P}V$ …(i)

In second case

$P\Delta V = -nR\Delta T$

$\Delta V = -\frac{nR\Delta T}{P}$ …(ii)

equating (i) and (ii)

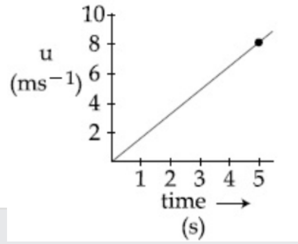
$\frac{nR\Delta T}{P} = -\frac{\Delta P}{P}V$

$\Delta T = \Delta P\,\frac{V}{nR}$

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

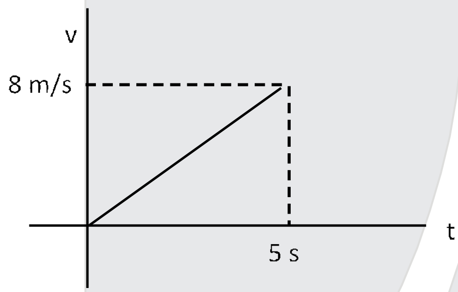
Putting the value of V, n and R , C = 150

24. The speed verses time graph for a particle is shown in the figure. The distance travelled (in m) by the particle during the time interval t = 0 to t = 5 s will be …..



Ans. **20.00**

Sol.



Distance = Area of |v| – t graph

= 1/2 × 8 × 5 = 20 m

25. Orange light of wavelength 6000×10^{-10} m illuminates a single slit of width 0.6×10^{-4} m. the maximum possible number of diffraction minima produced on both sides of the central maximum is :….

Ans. **200**

Sol. Light of wavelength 6000×10^{-10} m passes through a single slit of width 0.6×10^{-4} m. Find height of highest order of minima on both side central maxima

for minima

$d\sin\theta = n\lambda$

$\sin\theta = \frac{n\lambda}{d} < 1$

$n \le \frac{d}{\lambda}$

$n < \frac{0.6 \times 10^{-4}}{6000 \times 10^{-10}}$

$n < 100$

The total number of maxima of both side at central maxima = 100 + 100 = 200