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Unleashing Potential

JEE MAIN 2021

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

QUESTIONS & SOLUTIONS

Reproduced from Memory Retention

17 March, 2021 SHIFT-2

03:00 pm to 06:00 pm

Duration : 3 Hours Max. Marks : 300

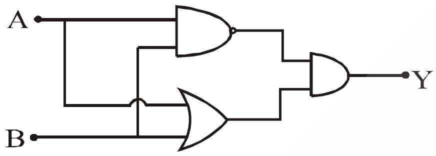
SUBJECT - PHYSICS

A-10, Road No.1, IPIA, Kota-324005 (Rajasthan), India
Tel. : +91-744-2665544 I Website : www.reliablekota.com I E-mail : info@reliablekota.com

JEE(MAIN) 2021 (17 MARCH ATTEMPT) SHIFT-2

PHYSICS

1. What will be equivalent logic gate for the circuit.



(1) AND (2) NAND (3) NOR (4) XOR

Ans. (4)

Sol. $Y = \left(\overline{A.B}\right).\left(A + B\right)$

$Y = \left(\overline{A} + \overline{B}\right).\left(A + B\right)$

$Y = \overline{A}A + \overline{A}B + \overline{B}.A + \overline{B}B \Rightarrow Y = \overline{A}B + \overline{B}A$

XOR gate

2. For a satellite at a distance 11 R from the surface of a planet P of radius R its time period is 24 hrs.

Evaluate time period of another satellite at distance 2R from the surface of P.

Ans. 3.00

Sol. $T \propto R^{\frac{3}{2}}$

$$\frac{T_1}{T_2} = \left(\frac{R_1}{R_2}\right)^{\frac{3}{2}}$$

$$\frac{24}{T_2} = \left(\frac{12R}{3R}\right)^{\frac{3}{2}}$$

$$\frac{24}{T_2} = 8$$

$T_2 = 3$ hr

3. A particle is moving along x-axis whose velocity is given by $v = v_0 + gt + ft^2$ (where g and f are constants). If at t = 0 particle is at x = 0 then the position of particle at t = 1 sec is given by.

(1) $v_0 + \frac{g}{2} + \frac{f}{3}$ (2) $v_0 + g + f$ (3) $v_0 - \frac{g}{2} + \frac{f}{2}$ (4) $v_0 + g + 2f$

Ans. (1)

Sol. $\frac{dx}{dt} = v_0 + gt + ft^2$

$$\int_0^x dx = \int_0^1 (v_0 + gt + ft^2)dt$$

$$x = \left[v_0 t + \frac{gt^2}{2} + \frac{ft^3}{3}\right]_0^1$$

$$x = v_0 + \frac{g}{2} + \frac{f}{3}$$

4. In a pure inductive circuit effect on reactance and current when frequency is halved

(1) reactance will be doubled and current will be halved

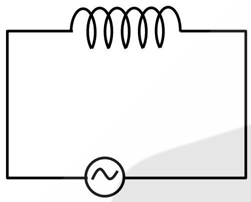
(2) current will be doubled and reactance will be halved.

(3) both doubled

(4) both halved

Ans. (2)

Sol.



$E_0 \sin\omega t$

$\because\ x_L = 2\pi f\ell$

$\therefore\ x_L$ will be halved.

$I_0 = \frac{E_0}{x_L}$

Current will be doubled.

5. 1 mole polyatomic gas with 2 vibration modes. If $\beta = \frac{C_P}{C_V}$, then β is:

(1) 1.02 (2) 1.25 (3) 1.4 (4) 1.66

Ans. (2)

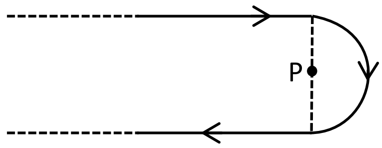
Sol. f = 3 + 3 + 2 = 8

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

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

$\beta = \frac{C_P}{C_V} = \frac{f+2}{f} = \frac{8+2}{8} = \frac{5}{4} = 1.25$

6. P is the centre of semi circular loop then magnetic field at P is.



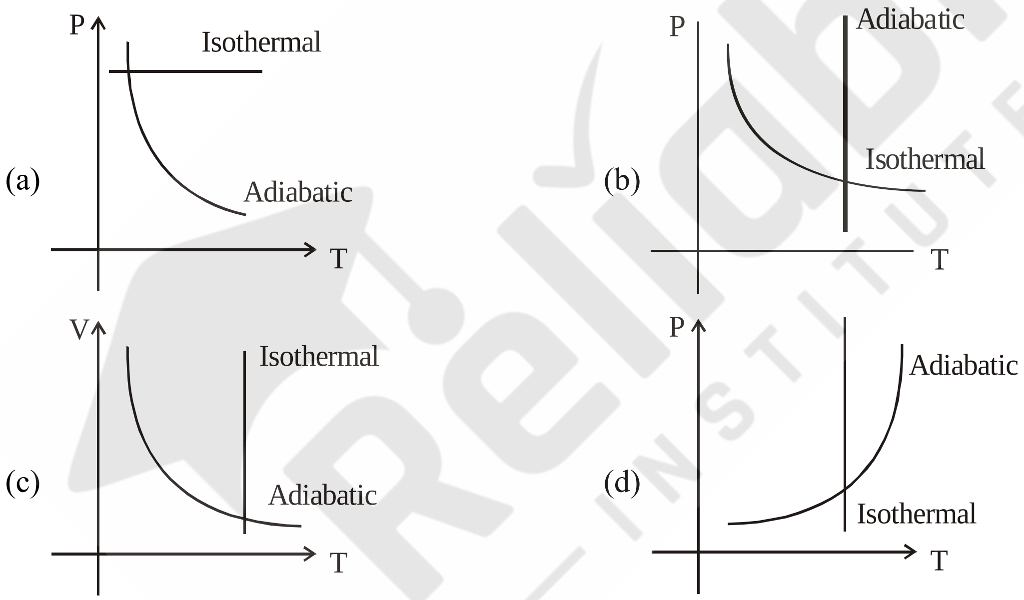
(1) $\frac{\mu_0 I}{2\pi R}\times(2+\pi)$ (2) $\frac{\mu_0 I}{2\pi R}(2-\pi)$ (3) $\frac{\mu_0 I}{4\pi R}(2+\pi)$ (4) $\frac{\mu_0 I}{4\pi R}(2-\pi)$

Ans. (1)

Sol. $B = \frac{\mu_0 I}{4\pi R}\times 2+\frac{\mu_0 I}{4R}$

$= \frac{\mu_0 I}{4\pi R}[2+\pi]$

7. Sample of gases are taken through isothermal and adiabatic process. Choose which of the following diagram correctly represent isothermal and adiabatic process.



(1) a and c (2) b and d (3) c only (4) c and d

Ans. **(4)**

Sol. * Isothermal process means constant temperature which is only possible in graph (c) and (d)

* for Adiabatic process

pV^{γ} = constant

$p^{1-\gamma} . T^{\gamma}$ = constant

or $T . V^{\gamma-1}$ = constant

8. Find out electric flux $\left(\text{in } \frac{\text{N.m}^2}{\text{C}}\right)$ passing through yz-plane with area A = 0.4 m^2 and electric field

$\vec{E} = \frac{2E_0}{5}\hat{i} + \frac{3E_0}{5}\hat{j}$, where $E_0 = 4 \times 10^3$ N/C

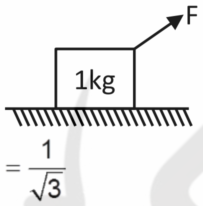
Ans. 640

Sol. $\vec{A} = 0.4\hat{i}$, $\vec{E} = \frac{2E_0}{5}\hat{i} + \frac{3E_0}{5}\hat{j}$

$\phi = \vec{E}.\vec{A} = \frac{2E_0}{5} \times 0.4 = \frac{0.8}{5} \times 4 \times 10^3 = 640$

9. A block of mass 1 kg on rough horizontal surface of friction coefficient $\mu = \frac{1}{\sqrt{3}}$ as shown in figure.

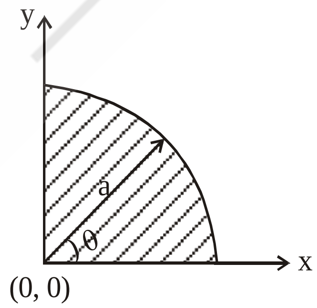
Find out F_{min} so that it can slide on surface (in N)



Ans. 5.00

Sol. $F_{min} = \frac{\mu mg}{\sqrt{L+\mu^2}} = \frac{\frac{1}{\sqrt{3}} \times 10}{\sqrt{L+\frac{1}{3}}} = 5\text{N}$

10. The diagram shows a quarter disc having uniform mass distribution. If coordinate of centre of mass is $\left(\frac{xa}{3\pi}; \frac{xa}{3\pi}\right)$ then x = __________

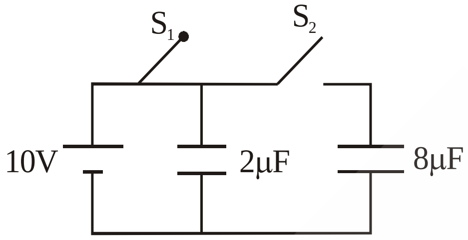


Ans. 4

Sol. Since it is a portion of half disc

so $y_{com} = \frac{4a}{3\pi}$ similarly $x_{com} = \frac{4a}{3\pi}$

11. A 2μF capacitor is charged with 10 volt cell. Now cell is removed and this capacitor is connected with uncharged 8 μf capacitor. Find out final charge on 8μF capacitor.



(1) 16μC (2) 8μC (3) 12μC (4) 2μC

Ans. (1)

Sol. $v = \frac{c_1v_1 + c_2v_2}{c_1 + c_2} = \frac{2\times10 + 8\times0}{2+8} = 2\,\text{volt}$

q= CV = 8 × 2 = 16 μC

12. The potential energy of a particle moving in a circular path is given by U = U_0r^4 where r is the radius of circular path. Assume Bohr model to be valid. The radius of n^{th} orbit is $r \propto n^{1/\alpha}$ where α is :

Ans. **3.00**

Sol. $\vec{F} = -\frac{dU}{dr}\hat{r} = -4U_0r^3\hat{r}$

$\frac{mv^2}{r} = 4U_0r^3 \quad \Rightarrow \quad mv^2 = 4U_0r^4$

$mvr = \frac{nh}{2\pi} \Rightarrow m\sqrt{\frac{4U_0}{m}}\, r^2.r = \frac{nh}{2\pi}$

$r \propto n^{1/3}$

$\alpha = 3$

13. Two equal masses A & B are connected to two different springs of spring constants k_1 & k_2 respectively. They are performing SHM such that they have same maximum velocities, then find the ratio of their amplitudes.

(1) $\sqrt{\frac{k_2}{k_1}}$ (2) $\sqrt{\frac{k_1}{k_2}}$ (3) $\frac{k_1}{k_2}$ (4) $\frac{k_2}{k_1}$

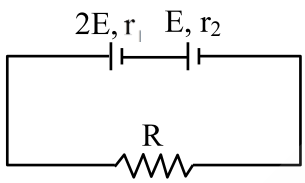
Ans. (1)

Sol. $A_1\,\omega_1 = A_2\omega_2$

$A_1\sqrt{\frac{k_1}{m}} = A_2\sqrt{\frac{k_2}{m}}$

$\frac{A_1}{A_2} = \sqrt{\frac{k_2}{k_1}}$

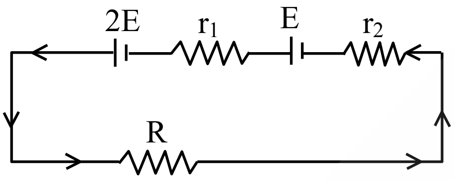
14. Internal resistance of battery of EMF 2E is r_1 and battery of EMF E is r_2. If potential difference across the battery of EMF 2E is zero then value of R is :



(1) $\frac{r_2}{2} - r_\perp$ (2) $\frac{r_1}{2} - r_2$ (3) $\frac{r_1}{2} + r_2$ (4) $\frac{r_2}{2} + r_1$

Ans. **(2)**

Sol.



$2E - Ir_1 = 0$

$3E = IR_{er.}$

$3E = I(R + r_1 + r_2)$

$3E = \frac{2E}{r_1}(R + r_1 + r_2)$, $\frac{3r_1}{2} = R + r_1 + r_2$

$R = \left(\frac{r_1}{2} - r_2\right)$

15. Visible light is found in which spectrum

(1) Lyman series (2) Balmer series (3) Pashen series (4) Pfund series

Ans. **(2)**

16. For a block at height 2 km from the base of a pond $\frac{\Delta v}{v}$ is 1.36%. Density of liquid is 1000 kg/m^3 and g = 9.8 ms^{-2}. Evaluate (hydraulic stress/ hydraulic strain).

(1) 14.41×10^5 N/m^2 (2) 1.41×10^5 N/m^2 (3) 17×10^6 N/m^2 (4) 1.7×10^6 N/m^2

Ans. (1)

Sol. Hydraulic stress = ρgh

$= 1000 \times 9.8 \times 2$

Hydraulic strain = $\frac{1.36}{100}$

$\Rightarrow \frac{\text{stress}}{\text{strain}} = \frac{19.6 \times 1000 \times 100}{1.36}$

$= 14.41 \times 10^5$ N/m^2

17. Match the phase of voltage and current given in column II with the circuit given in column I.

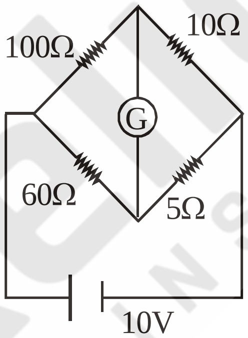
Column I	Column II
(a) Pure inductive circuit	(i) Current lags by $\frac{\pi}{2}$
(b) Pure capacitive circuit	(ii) Current leads by $\frac{\pi}{2}$
(c) Series LCR circuit	(iii) current and voltage are in same phase
(d) Pure resistive circuit	(iv) $\phi = \tan^{-1}\left(\frac{X_L - X_C}{R}\right)$

(1) a – (iv); b – (ii); c – (i); d – (iii)
(2) a – (iii); b – (ii); c – (iv); d – (i)
(3) a – (i); b – (iii); c – (iv); d – (ii)
(4) a – (i); b – (ii); c – (iii); d – (iv)

Ans. (4)

Sol. Theoretical.

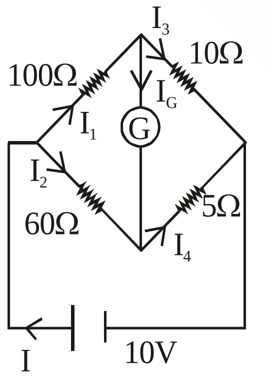
18. In given circuit galvanometer is ideal then find out current through galvanometer.



(1) 9.4 mA (2) 10.4 mA (3) 6.5 mA (4) 5.4 mA

Ans. (1)

Sol.



$$R_{eq} = \frac{100 \times 60}{160} + \frac{10 \times 5}{15}$$

$R_{eq} = 40.833$

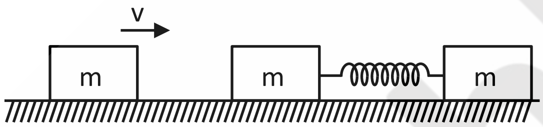
$I = \frac{10}{40.833} = 0.2448A$

$I_1 = \frac{I \times 60}{160} = \frac{3I}{8} = 0.091A$

$I_3 = \frac{I \times 5}{15} = \frac{I}{3} = 0.0816$

$I_G = 0.0094$ A = 9.4 mA

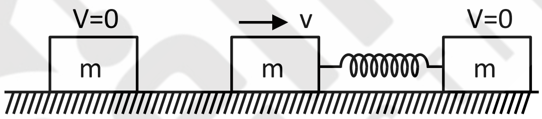
19. Two blocks of mass 'm' each are connected by an ideal spring and are kept on a smooth horizontal surface with the spring in its natural length. Another block of mass 'm' moving with speed 'v' collides with spring-block system, then find maximum compression in spring in subsequent motion.



(1) $\sqrt{\frac{m}{2k}}v$ (2) $\sqrt{\frac{mv}{2k}}$ (3) $\sqrt{\frac{m}{2kv}}$ (4) $\sqrt{\frac{mv}{k}}$

Ans. (1)

Sol. Assuming elastic collision, just after collision,



$\frac{1}{2}kx_{max}^2 = \frac{1}{2}\mu v_{rel}^2$

$\frac{1}{2}kx_{max}^2 = \frac{1}{2}\frac{m}{2}v^2$

$x_{max} = \sqrt{\frac{m}{2k}}\,v$

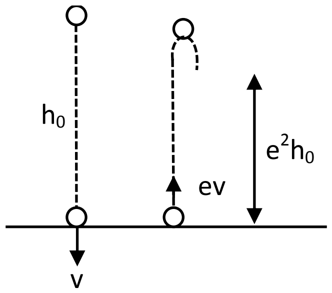
& only option dimensionally correct is (A)

20. A particle is dropped from a height of 5 m above ground. The consecutive height attained after each collision is $\frac{81}{100}$ of previous collision. Find average speed of ball. ($g = 10\ m/s^2$)

(1) 3.0 (2) 2.5 (3) 2.0 (4) 3.5

Ans. (2)

Sol.



$e^2 h_0 = \frac{81}{100} h_0 \Rightarrow e = 0.9$

Distance $= h_0 + 2e^2 h_0 + 2e^4 h_0 + \ldots\ldots\ldots$

$= h_0 + 2e^2 h_0 (1 + e^2 + \ldots\ldots\ldots..)$

$= h_0 + 2e^2 h_0 \left(\frac{1}{1-e^2}\right) = h_0\left[\frac{1+e^2}{1-e^2}\right]$

time $= \sqrt{\frac{2h_0}{g}} + 2e\sqrt{\frac{2h_0}{g}} + 2e^2\sqrt{\frac{2h_0}{g}} + \ldots\ldots\ldots$

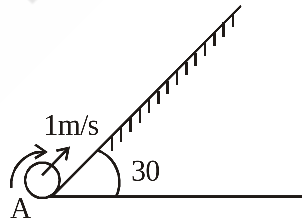
$= \sqrt{\frac{2h_0}{g}}\ [1 + 2e + 2e^2 + \ldots\ldots\ldots..] = \sqrt{\frac{2h_0}{g}}\left[1 + 2e\left(\frac{1}{1-e}\right)\right]$

$= \sqrt{\frac{2h_0}{g}}\left(\frac{1+e}{1-e}\right)$

Avg speed $= \frac{h_0\left(\frac{1+e^2}{1-e^2}\right)}{\sqrt{\frac{2h_0}{g}}\left(\frac{1+e}{1-e}\right)} = \sqrt{\frac{gh_0}{2}}\frac{(1+e^2)}{(1-e^2)}\frac{(1-e)}{(1+e)}$

$= 5\ \frac{(1.81)}{(0.19)}\frac{(0.1)}{(1.9)} = 2.50$

21. A solid sphere of mass 2 kg and radius 0.5 m is projected from point A on a rough inclined plane as shown in figure. If it rolls without sliding find the time taken to reach again at A



(1) 0.56 sec (2) 1.13 sec (3) 0.47 sec (4) 0.35 sec

Ans. (1)

Sol. $a = \dfrac{g\sin\theta}{1+\dfrac{I}{mR^2}} = \dfrac{10\times\dfrac{1}{2}}{\left(1+\dfrac{\frac{2}{5}mR^2}{mR^2}\right)} = \dfrac{25}{7}m/s^2$

$t_{up} = \dfrac{u}{a} = \dfrac{1}{\frac{25}{7}} = \dfrac{7}{25}\text{sec}$

$t_{up} = t_{down} \Rightarrow T = 2t = \dfrac{14}{25}$ sec = 0.56 sec

22. A carrier $y_c = A_c\sin\omega_c t$ modulates a message signal $y_m = A_m\sin\omega_m t$. Evaluate its linear band width whose $\omega_m = 1.57 \times 10^8$ rad/s

(1) 19.72×10^8 Hz (2) 19.72×10^6 Hz (3) 10^8 Hz (4) 5×10^6 Hz

Ans. **(3)**

Sol. Band width = $(1.57 \times 10^8)2$

23. A wave is travelling in possible x-direction with speed 300 m/s and frequency 239 Hz. It maximum distance travelled by a point during to and fro motion is 6 cm. Find out equation of wave on a string.

(1) $y = 0.06 \sin (5.1\,x - 1.5 \times 10^3\,t)$ (2) $y = 0.03 \sin (5.1\,x + 1.5 \times 10^3\,t)$

(3) $y = 0.06 \sin (5.1\,x + 1.5 \times 10^3\,t)$ (4) $y = 0.03 \sin (5.1\,x + 1.5 \times 10^3\,t)$

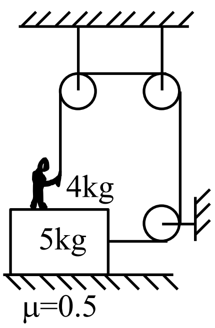
Ans. **(1)**

Sol. A = 30 cm = 0.6 m

$K = \dfrac{1500}{239} = 5.1/m$

$y = 0.06 \sin (5.1\,x - 1.5 \times 10^3\,t)$

24. Find the minimum value of force (in N) man should apply so that block can move :



Ans. **30.00**

Sol. $T + N_1 = 4g$

$N_2 = N_1 + 5g$

$T = f\ell$

$T = 0.5\ (4g - T + 5g)$

$1.5T = 0.5 \times 9g$

$T = 3g = 30N$

25. If Electric field at a distance 3m from 100 watt bulb is E then Electric field at 3m from 60 watt bulb is $\sqrt{\frac{x}{5}}E$. Find the value of x.

Ans. 3.00

Sol. $\frac{\rho}{4\pi r^2} \propto E^2$ ________(1)

$\frac{\rho_1}{\rho_2} = \frac{E_1^2}{E_2}$

$\frac{100}{60} = \frac{E_1^2}{E_2}$

$\therefore E_2\sqrt{\frac{3}{5}}\ E$

26. Initial amplitude of block of mass 1 kg undergoing damped oscillation is 12 cm. If amplitude at t = 20 minutes is A = 6 cm then find the value of damping constant. (in SI units)

(1) 1.16×10^{-3} (2) 1.15×10^{-3} (3) 1.13×10^{-3} (4) 1.12×10^{-3}

Ans. **(1)**

Sol. $A = A_0 \times e^{-bt/2m}$

$\mathbf{6 = 12} \times e^{-bt/2}$

$\ln 2 = bt/2$

$b = 1.16 \times 10^{-3}$ kg/s.

27. Coming soon.

28. Coming soon.

29. Coming soon.

30. Coming soon.