

PHYSICS for you

Volume 25 No. 4

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Physics Musing was started in August 2013 issue of Physics For You. The aim of Physics Musing is to augment the chances of bright students preparing for JEE (Main and Advanced) / AIIMS / NEET / Other PMTs with additional study material.

In every issue of Physics For You, 10 challenging problems are proposed in various topics of JEE (Main and Advanced) / various PMTs. The detailed solutions of these problems will be published in next issue of Physics For You.

The readers who have solved five or more problems may send their detailed solutions with their names and complete address. The names of those who send atleast five correct solutions will be published in the next issue.

We hope that our readers will enrich their problem solving skills through "Physics Musing" and stand in better stead while facing the competitive exams.

PROBLEM Set 45

SINGLE OPTION CORRECT TYPE

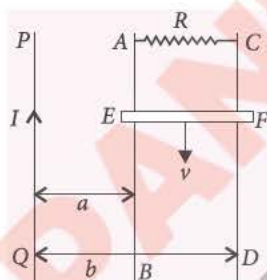
1. PQ is an infinite current carrying conductor. AB and CD are smooth conducting rods on which a conductor EF moves with constant velocity v as shown in figure. The force needed to maintain constant speed of EF is (No gravity is there.)

(a) $\frac{1}{vR} \left[\frac{\mu_0 I v}{2\pi} \ln\left(\frac{b}{a}\right) \right]^2$

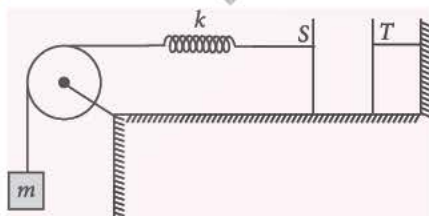
(b) $\frac{1}{R} \left[\frac{\mu_0 I v}{2\pi} \ln\left(\frac{b}{a}\right) \right]^2$

(c) $\frac{v}{R} \left[\frac{\mu_0 I v}{2\pi} \ln\left(\frac{b}{a}\right) \right]^2$

(d) $\frac{v}{R} \left[\frac{\mu_0 I v}{2\pi} \ln\left(\frac{b}{a}\right) \right]^2$



2. The plates S and T of an uncharged parallel plate capacitor are connected across a battery. The battery is then disconnected and the charged plates are now connected in a system as shown in the figure. The system shown is in equilibrium. All the strings are insulating and massless and spring constant of massless spring is k . The magnitude of charge on one of the capacitor plates is (Area of each plate is A.)



(a) $\sqrt{2mgA\epsilon_0}$

(b) $\sqrt{\frac{4mgA\epsilon_0}{k}}$

(c) $\sqrt{mgA\epsilon_0}$ (d) $\sqrt{\frac{2mgA\epsilon_0}{k}}$

3. A ring carries uniform charge Q and has radius R . The electric field at a small distance x from the centre along the radius will be

(a) $\frac{Qx}{4\pi\epsilon_0 R^3}$ (b) $\frac{Qx}{8\pi\epsilon_0 R^3}$

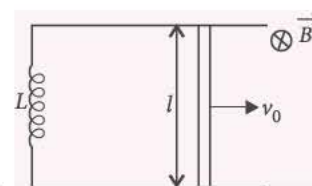
(c) $\frac{Qx}{12\pi\epsilon_0 R^3}$ (d) $\frac{Qx}{16\pi\epsilon_0 R^3}$

4. Consider a cubical container containing only photons. Assuming that photons behave like ideal gas then the relation between the pressure (P) and average energy density (u) will be (Assuming only photons exists.)

(a) $P = \frac{u}{3}$ (b) $P = \frac{2u}{3}$

(c) $P = \frac{3}{2}u$ (d) $P = u$

5. Two ends of an inductor of inductance L are connected to two parallel conducting wires. A rod of length



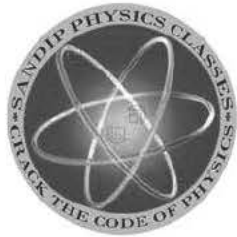
l and mass m is given velocity v_0 as shown in figure. The whole system is placed in perpendicular magnetic field B . Find the maximum current in the inductor. (Neglect gravity and friction)

(a) $\frac{mv_0}{L}$

(b) $\sqrt{\frac{m}{L}} v_0$

(c) $\frac{mv_0^2}{L}$

(d) None of these



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About the mentor:

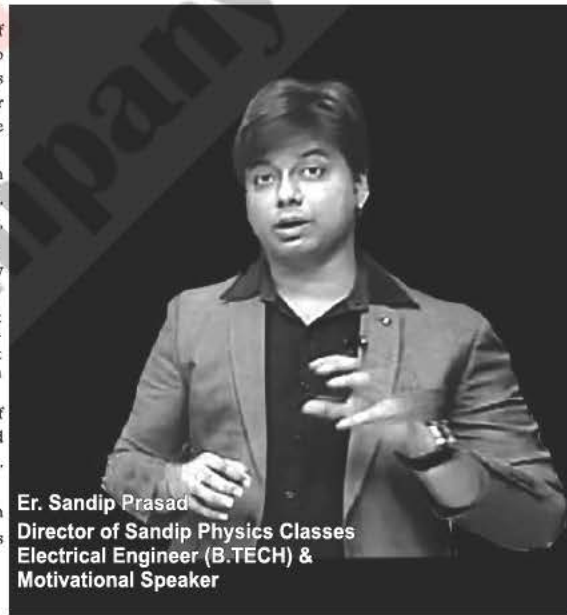
Er. Sandip Prasad is one of the most sought after and famous Physics teachers of India for IIT-JEE, Engineering and medical Entrance Examinations, who founded Sandip Physics Classes (SFC) 8 years ago. SFC which has several centres in Kolkata and Patna has been guiding students, aspiring to be IITians and for all other medical and engineering entrance examinations. Many of his students have successfully cracked the IIT, AIIMS, AIPMT, WBJEE, and other exams.

His superhit show "IIT Made Easy by Sandip Sir", is a unique initiative which stressed on the importance of motivation along with the knowledge of the subject, as an essential raw material to crack the exams. The 35-episodes long show, which he recently wrapped up used to be telecasted on Taaza tv (Eastern India's only Hindi news channel), every Sunday. The show gained unprecedented popularity and viewership.

He is also a columnist of one of West Bengal's highest selling Hindi daily Prabhat Khabar, where his career counseling articles are published every Saturday. (The e-paper of Kolkata Edition of Prabhat Khabar can be found at www.prabhathkhabar.com. You may also mail your career related queries to the given address).

An eminent speaker, he has conducted several motivational seminars in some of the most reputed schools of Kolkata. News about his seminars, results and contribution have also been printed in dailies like Sanmarg, Dainik Jagran, Chaptre Chaptre.

A man of absolute devotion, he leaves no stone unturned to help his students with his deep understanding of the subject and amazing problem-solving tricks. It is not surprising that the best and most brilliant of students hold him as their ideal.



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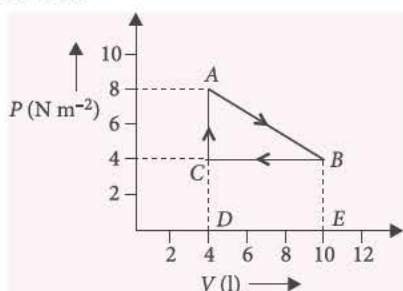
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MULTIPLE OPTION CORRECT TYPE

6. The diagram shows the P - V diagram of a cyclic process $ABCA$.



- (a) Work done in process $A \rightarrow B$ is 0.036 J.
 (b) Work done in process $B \rightarrow C$ is -0.024 J.
 (c) Work done in process $C \rightarrow A$ is zero.
 (d) Work done in cycle $ABCA$ is 0.06 J.

7. An ideal gas undergoes an expansion from a state with temperature T_1 and volume V_1 to V_2 through three different polytropic processes A , B and C as shown in the P - V

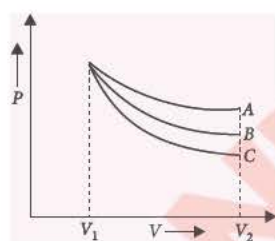


diagram. If $|\Delta U_A|$, $|\Delta U_B|$ and $|\Delta U_C|$ be the magnitude of changes in internal energy along the three paths respectively, then

- (a) $|\Delta U_A| < |\Delta U_B| < |\Delta U_C|$ if temperature in every process decreases
 (b) $|\Delta U_A| > |\Delta U_B| > |\Delta U_C|$ if temperature in every process decreases
 (c) $|\Delta U_A| > |\Delta U_B| > |\Delta U_C|$ if temperature in every process increases
 (d) $|\Delta U_A| < |\Delta U_B| < |\Delta U_C|$ if temperature in every process increases
8. A partition divides a container having insulated walls into two compartments I and II. The same gas fills the two compartments whose initial parameters are given. The partition is a conducting wall which can move freely without friction. Which of the following statements is/are correct, with reference to the final equilibrium position?

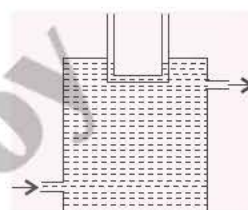
P, V, T I	$2P, 2V, T$ II
----------------	-------------------

- (a) The pressure in the two compartments are equal.

- (b) Volume of compartment I is $\frac{3V}{5}$
 (c) Volume of compartment II is $\frac{12V}{5}$
 (d) Final pressure in compartment I is $\frac{5P}{3}$

INTEGER TYPE

9. A conducting tube is passing through a bath. A liquid at temperature 90°C and specific heat s is entering at one end of tube. Rate of flow of liquid is 1 kg s^{-1} and exit temperature is 50°C . In bath another liquid having specific heat $2s$ and inlet temperature 20°C is entering at a rate of 2 kg s^{-1} . If the exit temperature of liquid coming out of the bath is $10x$. Find x (in $^\circ\text{C}$). (Assume steady state condition)



10. Heat is generated uniformly per unit volume inside a spherical volume of radius 1 m at rate of 20 W m^{-3} . The thermal conductivity of the spherical volume is $\frac{1}{6} \text{ W m}^{-1} \text{ }^\circ\text{C}^{-1}$ and the temperature of outer surface of the sphere is 20°C . If the temperature of the centre of the sphere is $x \times 10$ (in $^\circ\text{C}$), find x .

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1. The measurement of two quantities is given as $A = 1.0 \text{ m} \pm 0.2 \text{ m}$ and $B = 2.0 \text{ m} \pm 0.2 \text{ m}$.

The correct value for \sqrt{AB} is

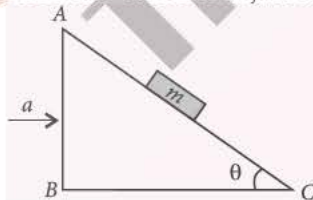
- (a) $1.4 \text{ m} \pm 0.4 \text{ m}$ (b) $1.41 \text{ m} \pm 0.15 \text{ m}$
(c) $1.4 \text{ m} \pm 0.3 \text{ m}$ (d) $1.4 \text{ m} \pm 0.2 \text{ m}$

2. A particle moving along x -axis has acceleration a , at time t , given by $a = a_0 \left(1 - \frac{t}{T}\right)$, where a_0 and T are constants. The particle has zero velocity at $t = 0$. In the time interval between $t = 0$ and the instant when $a = 0$, the particle's velocity v_x is

- (a) $\frac{1}{2}a_0T^2$ (b) a_0T^2
(c) $\frac{1}{2}a_0T$ (d) a_0T

3. One coolie takes 1 minute to raise a suitcase through a height of 2 m but the second coolie takes 30 s to raise the same suitcase to the same height. The powers of two coolies are in the ratio
(a) 1 : 3 (b) 2 : 1 (c) 3 : 1 (d) 1 : 2

4. A body of mass m is resting on a wedge of angle θ as shown in figure. The wedge is given an acceleration a . The value of a so that the mass m just falls freely is



- (a) g (b) $g \sin\theta$ (c) $g \tan\theta$ (d) $g \cot\theta$

5. When the angle of projection is 75° , a ball falls 10 m short of the target. When the angle of projection is 45° , it falls 10 m ahead of the target. Both are projected from the same point with the

same speed in the same direction. The distance of the target from the point of projection is

- (a) 15 m (b) 30 m (c) 45 m (d) 10 m

6. A ball of mass m is thrown upwards with a velocity v . If air exerts an average resisting force F , the velocity with which the ball returns to the thrower is

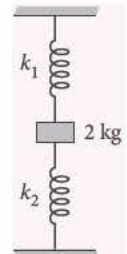
- (a) $v \sqrt{\frac{mg}{mg+F}}$ (b) $v \sqrt{\frac{m}{mg+F}}$

- (c) $v \sqrt{\frac{mg-F}{mg+F}}$ (d) $v \sqrt{\frac{mg+F}{mg}}$

7. A 2 kg block is connected with two springs of force constants $k_1 = 100 \text{ N m}^{-1}$ and $k_2 = 300 \text{ N m}^{-1}$ as shown in figure. The block is released from rest with the springs unstretched.

The acceleration of the block in its lowest position is ($g = 10 \text{ m s}^{-2}$)

- (a) zero
(b) 10 m s^{-2} upwards
(c) 10 m s^{-2} downwards
(d) 5 m s^{-2} upwards



8. A ball is released from the top of an inclined plane of inclination θ . It reaches the bottom with velocity v . If the angle of inclination is doubled, then the velocity of ball on reaching the ground is

- (a) v (b) $2v$
(c) $v\sqrt{2 \cos\theta}$ (d) $v\sqrt{2 \sin\theta}$

9. If a sphere is rolling, the ratio of the translational energy to total kinetic energy is given by

- (a) 7 : 10 (b) 2 : 5 (c) 10 : 7 (d) 5 : 7

10. The radii of circular orbits of two satellites A and B of the earth are $4R$ and R respectively. If the speed of satellite A is $3v$, then the speed of satellite B will be

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- (a) $\frac{3v}{4}$ (b) $6v$ (c) $12v$ (d) $\frac{3v}{2}$

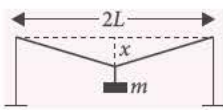
11. A body of mass m is taken from the earth's surface to the height equal to twice the radius R of the earth. The change in potential energy of body will be

- (a) $3mgR$ (b) $\frac{1}{3}mgR$ (c) $2mgR$ (d) $\frac{2}{3}mgR$

12. The density of water at 20°C is 998 kg m^{-3} and at 40°C , 992 kg m^{-3} . The coefficient of volume expansion of water is

- (a) $3 \times 10^{-4} \text{ }^\circ\text{C}^{-1}$ (b) $2 \times 10^{-4} \text{ }^\circ\text{C}^{-1}$
(c) $6 \times 10^{-4} \text{ }^\circ\text{C}^{-1}$ (d) $10^{-4} \text{ }^\circ\text{C}^{-1}$

13. A mild steel wire of length $2L$ and cross-sectional area A is stretched, well within elastic limit, horizontally between two pillars as shown in the figure. A mass m is suspended from the mid-point of the wire. Strain in the wire is



- (a) $\frac{x^2}{2L^2}$ (b) $\frac{x}{L}$ (c) $\frac{x^2}{L}$ (d) $\frac{x^2}{2L}$

14. Two mercury droplets of radii 0.1 cm and 0.2 cm collapse into one single drop. The amount of energy released is (The surface tension of mercury $T = 435.5 \times 10^{-3}\text{ N m}^{-1}$)

- (a) $32 \times 10^{-7}\text{ J}$ (b) $30 \times 10^{-7}\text{ J}$
(c) $28 \times 10^{-7}\text{ J}$ (d) $31 \times 10^{-7}\text{ J}$

15. A copper block of mass 2.5 kg is heated in a furnace to a temperature of 500°C and then placed on a large ice block. The maximum amount of ice that can melt is (Specific heat of copper $= 0.39\text{ J g}^{-1} \text{ }^\circ\text{C}^{-1}$, heat of fusion of water $= 335\text{ J g}^{-1}$).

- (a) 1.4 kg (b) 1.5 kg (c) 1.1 kg (d) 1.3 kg

16. The coefficient of volume expansion of glycerine is $49 \times 10^{-5} \text{ }^\circ\text{C}^{-1}$. The fractional change in its density for a 30°C rise in temperature is

- (a) 0.0145 (b) 0.0156 (c) 0.0167 (d) 0.0247

17. The efficiency of Carnot engine is 50% and temperature of sink is 500 K . If temperature of source is kept constant and its efficiency raised to 60% , then the required temperature of sink will be

- (a) 100 K (b) 600 K (c) 400 K (d) 500 K

18. A monatomic gas at pressure P_1 and volume V_1 is compressed adiabatically to $\left(\frac{1}{8}\right)^{\text{th}}$ of its original volume. The final pressure of the gas is

- (a) $64P_1$ (b) P_1 (c) $16P_1$ (d) $32P_1$

19. The driver of a car approaching a vertical wall notices that the frequency of the horn of his car changes from 400 Hz to 450 Hz after being reflected from the wall. Assuming speed of sound to be 340 m s^{-1} , the speed of approach of car towards the wall is

- (a) 10 m s^{-1} (b) 20 m s^{-1}
(c) 30 m s^{-1} (d) 40 m s^{-1}

20. A siren placed at a railway platform is emitting sound of frequency 5 kHz . A passenger sitting in a moving train A records a frequency of 5.5 kHz while the train approaches the siren. During his return journey in a different train B he records a frequency of 6.0 kHz while approaching the same siren. The ratio of velocity of train B to that of train A is

- (a) $242/252$ (b) 2
(c) $5/6$ (d) $11/6$

21. The potential energy of a simple harmonic oscillator of mass 2 kg in its mean position is 5 J . If its total energy is 9 J and its amplitude is 0.01 m , its time period would be

- (a) $\pi/10\text{ s}$ (b) $\pi/20\text{ s}$ (c) $\pi/50\text{ s}$ (d) $\pi/100\text{ s}$

22. If potential (in volts) in a region is expressed as $V(x, y, z) = 6xy - y + 2yz$, the electric field (in N C^{-1}) at point $(1, 1, 0)$ is

- (a) $-(2\hat{i} + 3\hat{j} + \hat{k})$ (b) $-(6\hat{i} + 9\hat{j} + \hat{k})$
(c) $-(3\hat{i} + 5\hat{j} + 3\hat{k})$ (d) $-(6\hat{i} + 5\hat{j} + 2\hat{k})$

23. Capacity of an isolated sphere is increased by n times when it is enclosed by an earthed concentric sphere. The ratio of their radii is

- (a) $\frac{n}{n-1}$ (b) $\frac{n^2}{n-1}$ (c) $\frac{2n}{n+1}$ (d) $\frac{2n+1}{n+1}$

24. Two point charges $+3\text{ }\mu\text{C}$ and $+8\text{ }\mu\text{C}$ repel each other with a force of 40 N . If a charge of $-5\text{ }\mu\text{C}$ is added to each of them, then the force between them will become

- (a) -10 N (b) $+10\text{ N}$ (c) $+20\text{ N}$ (d) -20 N

25. The internal resistance of a 2.1 V cell which gives a current of 0.2 A through a resistance of $10\text{ }\Omega$ is

- (a) $0.8\text{ }\Omega$ (b) $1.0\text{ }\Omega$ (c) $0.2\text{ }\Omega$ (d) $0.5\text{ }\Omega$

26. A wire of resistance $4\text{ }\Omega$ is stretched to twice of its original length. The resistance of stretched wire would be

- (a) $8\text{ }\Omega$ (b) $16\text{ }\Omega$ (c) $2\text{ }\Omega$ (d) $4\text{ }\Omega$

27. The intensity of magnetic field at a point X on the axis of a small magnet is equal to the field intensity at another point Y on its equatorial axis. The ratio of distance of X and Y from the centre of the magnet will be
 (a) 2^{-3} (b) $2^{-1/3}$ (c) 2^3 (d) $2^{1/3}$
28. A proton, a deuteron and an α -particle enter a region of uniform magnetic field B perpendicularly, with the same kinetic energy. The ratio of the radius of their circular paths is
 (a) $1:\sqrt{2}:1$ (b) $1:\sqrt{2}:\sqrt{2}$
 (c) $\sqrt{2}:1:1$ (d) $\sqrt{2}:\sqrt{2}:1$
29. In an inductor of self inductance $L = 2$ mH, current changes with time according to the relation $I = t^2 e^{-t}$. The time at which the emf becomes zero is
 (a) 4 s (b) 2 s (c) 1 s (d) 0.5 s
30. A coil is placed in a transverse magnetic field of 0.02 T. If this coil starts shrinking at a rate of 1 mm s^{-1} , while its radius remains 4 cm, then the value of induced emf is
 (a) $2 \mu\text{V}$ (b) $5 \mu\text{V}$ (c) $8 \mu\text{V}$ (d) $50 \mu\text{V}$
31. A resistor of resistance 30Ω , inductor of reactance 10Ω and capacitor of reactance 10Ω are connected in series to an ac voltage source $\varepsilon = 300\sqrt{2} \sin \omega t$. The current in the circuit is
 (a) $10\sqrt{2}$ A (b) 10 A
 (c) $30\sqrt{11}$ A (d) $30/\sqrt{11}$ A
32. A current of 2 A is increasing at a rate of 4 A s^{-1} through a coil of inductance 2 H. The energy stored in the inductor per unit time is
 (a) 16 J s^{-1} (b) 4 J s^{-1} (c) 2 J s^{-1} (d) 1 J s^{-1}
33. The magnetic field in a plane electromagnetic wave is given by,
 $B = (200 \mu\text{T}) \sin [(4.0 \times 10^{15} \text{ s}^{-1})(t - x/c)]$.
 The average energy density corresponding to the electric field is
 (a) $1.6 \times 10^{-2} \text{ J m}^{-3}$ (b) $8 \times 10^{-3} \text{ J m}^{-3}$
 (c) $3.2 \times 10^{-2} \text{ J m}^{-3}$ (d) $8 \times 10^{-4} \text{ J m}^{-3}$
34. Light from a point source in air falls on a convex spherical glass surface of refractive index $\mu = 1.5$ and radius of curvature $R = 20$ cm. The distance of light source from the glass surface is 100 cm. The distance of the image formed is
 (a) 100 cm (b) 200 cm
 (c) 300 cm (d) 120 cm
35. The radius of curvature of each surface of a convex lens of refractive index 1.5 is 40 cm. The power of the lens is
 (a) 1.5 D (b) 2.0 D (c) 2.5 D (d) 2.1 D
36. A ray of light passes through an equilateral glass prism, such that the angle of incidence is equal to the angle of emergence. If the angle of emergence is $3/4$ times the angle of the prism. The refractive index of the glass prism is
 (a) 1.414 (b) 1.214 (c) 1.523 (d) 1.423
37. A ray of light incident on an equilateral glass prism ($\mu_{\text{glass}} = \sqrt{3}$) moves parallel to the base of the prism inside it. The angle of incidence for this ray is
 (a) 60° (b) 90° (c) 30° (d) 45°
38. For photoelectric emission from certain metal the cut off frequency is ν . If radiation of frequency 2ν impinges on the metal plate, the maximum possible velocity of the emitted electron will be (m is the mass of electron)
 (a) $\sqrt{\frac{2h\nu}{m}}$ (b) $2\sqrt{\frac{h\nu}{m}}$ (c) $\sqrt{\frac{h\nu}{2m}}$ (d) $\sqrt{\frac{h\nu}{m}}$
39. When the energy of the incident radiation is increased by 20%, the kinetic energy of the photoelectrons emitted from a metal surface increased from 0.5 eV to 0.8 eV. The work function of the metal is
 (a) 0.65 eV (b) 1.0 eV
 (c) 1.3 eV (d) 1.5 eV
40. Two radiations of photon energies 1 eV and 2.5 eV, successively illuminate a photosensitive metallic surface of work function 0.5 eV. The ratio of the maximum speeds of the emitted electrons is
 (a) 1 : 4 (b) 1 : 2 (c) 1 : 1 (d) 1 : 5
41. Ratio of longest wavelengths corresponding to Lyman and Balmer series in hydrogen spectrum is
 (a) $\frac{9}{31}$ (b) $\frac{5}{27}$ (c) $\frac{3}{23}$ (d) $\frac{7}{29}$
42. A radioactive material decays by simultaneous emission of two particles with respective half lives 1620 and 810 years. The time in years, after which one fourth of the material remains is
 (a) 540 years (b) 1080 years
 (c) 118 years (d) 24 years
43. The capacitance of a spherical conductor of radius 1 m is
 (a) 9×10^{-9} F (b) $10 \mu\text{F}$
 (c) 1.1×10^{-10} F (d) $1 \mu\text{F}$

44. According to Bohr model of hydrogen atom, only those orbits are permissible which satisfy the condition

(a) $mv = n\hbar$ (b) $\frac{mv^2}{r} = n\left(\frac{h}{2\pi}\right)$

(c) $mvr = n\left(\frac{h}{2\pi}\right)$ (d) $mvr^2 = n\left(\frac{h}{2\pi}\right)$

45. When a coil carrying a steady current is short circuit, the current in it decreases η times in time t_0 . The time constant of the circuit is

(a) $\frac{t_0}{\ln \eta}$ (b) $\frac{t_0}{\eta - 1}$

(c) $t_0 \ln \eta$ (d) $\frac{t_0}{\eta}$

SOLUTIONS

1. (d)

2. (c): Given, At time $t = 0$, velocity, $v = 0$

Acceleration, $a = a_0\left(1 - \frac{t}{T}\right)$

When $a = 0$, $0 = a_0\left(1 - \frac{t}{T}\right)$ ($a_0 = \text{constant}$)

$\therefore 1 - \frac{t}{T} = 0$ or $t = T$.

Also, acceleration $a = \frac{dv}{dt}$

$\therefore \int_0^{v_x} dv = \int_{t=0}^{t=T} a dt = \int_0^T a_0\left(1 - \frac{t}{T}\right) dt$

$\therefore v_x = \left[a_0 t - \frac{a_0 t^2}{2T} \right]_0^T = a_0 T - \frac{a_0 T^2}{2T} = \frac{1}{2} a_0 T$

3. (d): Power, $P = \frac{\text{Work done}}{\text{Time taken}}$

Here, work done ($= mgh$) is same in both cases.

$\therefore \frac{P_1}{P_2} = \frac{t_2}{t_1} = \frac{30 \text{ s}}{1 \text{ minute}} = \frac{30 \text{ s}}{60 \text{ s}} = \frac{1}{2}$

4. (d): The horizontal acceleration a of the wedge should be such that in time the wedge moves the horizontal distance BC , the body must fall through a vertical distance AB under gravity. Hence,

$BC = \frac{1}{2} at^2$ and $AB = \frac{1}{2} gt^2$

$\tan \theta = \frac{AB}{BC} = \frac{g}{a}$ or $a = \frac{g}{\tan \theta} = g \cot \theta$

5. (b): Since, range $R = \frac{u^2 \sin 2\theta}{g}$

$\therefore \frac{u^2 \sin 2 \times 75^\circ}{g} = R - 10$... (i)

and $\frac{u^2 \sin 2 \times 45^\circ}{g} = R + 10$ or $\frac{u^2}{g} = R + 10$

$(R + 10) \sin 150^\circ = R - 10$ (from eqn. (i))

or $(R + 10) \frac{1}{2} = R - 10$

or $R = 30 \text{ m}$

6. (c): For upward motion, retarding force = $mg + F$

\therefore Retardation, $a = \frac{mg + F}{m}$

Distance, $s = \frac{v^2}{2a} = \frac{v^2 m}{2(mg + F)}$

For downward motion, net force = $mg - F$

\therefore Acceleration, $a' = \frac{mg - F}{m}$

Distance, $s' = \frac{v'^2}{2a'} = \frac{v'^2 m}{2(mg - F)}$

As $s = s' \therefore \frac{v^2 m}{2(mg + F)} = \frac{v'^2 m}{2(mg - F)}$

$\therefore v' = v \sqrt{\frac{mg - F}{mg + F}}$

7. (b): Here, $m = 2 \text{ kg}$, $k_1 = 100 \text{ N m}^{-1}$, $k_2 = 300 \text{ N m}^{-1}$

When block is released from rest, let its maximum downward displacement be x .

\therefore Decrease in potential energy of the block = Increase in potential energy of two springs

$mgx = \frac{1}{2}(k_1 + k_2)x^2$

$x = \frac{2mg}{k_1 + k_2} = \frac{2 \times 2 \times 10}{100 + 300} = 0.1 \text{ m}$

Acceleration of block in this position is

$a = \frac{(k_1 + k_2)x - mg}{m}$

$a = \frac{[(100 + 300)0.1] - [2 \times 10]}{2} = 10 \text{ m s}^{-2}$, upwards

8. (c): When inclination of plane is θ , the downward acceleration of body along the plane is

$a = g \sin \theta$

Using the relation, $v^2 = u^2 + 2as$, we have

$$v^2 = 0 + 2 \times g \sin \theta \times s$$

$$\text{or } v = \sqrt{2gs \sin \theta} \quad \dots(i)$$

When inclination of plane is 2θ , the downward acceleration of body along the plane is

$$a_1 = g \sin 2\theta$$

$$\text{Then } v_1^2 = 0 + 2g \sin 2\theta \times s$$

$$\text{or } v_1 = \sqrt{2gs \times 2 \sin \theta \cos \theta}$$

$$\therefore v_1/v = \sqrt{2 \cos \theta} \quad \text{or } v_1 = v\sqrt{2 \cos \theta}$$

9. (d)

10. (b): Orbital speed of the satellite around the earth

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

For satellite A, $r_A = 4R$, $v_A = 3v$

$$\therefore v_A = \sqrt{\frac{GM}{r_A}} \quad \dots(i)$$

For satellite B, $r_B = R$, $v_B = ?$

$$\therefore v_B = \sqrt{\frac{GM}{r_B}} \quad \dots(ii)$$

Dividing eqn. (ii) by eqn. (i), we get

$$\therefore \frac{v_B}{v_A} = \sqrt{\frac{r_A}{r_B}} \quad \text{or } v_B = v_A \sqrt{\frac{r_A}{r_B}}$$

Substituting the given values, we get

$$v_B = 3v \sqrt{\frac{4R}{R}} \quad \text{or } v_B = 6v$$

11. (d): Gravitational potential energy at any point at a distance r from the centre of the earth is

$$U = -\frac{GMm}{r}$$

At the surface of the earth, $r = R$

$$\therefore U_i = -\frac{GMm}{R}$$

At a height h from the surface,

$$r = R + h = R + 2R = 3R \quad (h = 2R \text{ (Given)})$$

$$\therefore U_f = -\frac{GMm}{3R}$$

Change in potential energy,

$$\Delta U = U_f - U_i = -\frac{GMm}{3R} - \left(-\frac{GMm}{R}\right)$$

$$= \frac{GMm}{R} \left(1 - \frac{1}{3}\right) = \frac{2}{3} \frac{GMm}{R} = \frac{2}{3} mgR \quad \left(\because g = \frac{GM}{R^2}\right)$$

12. (a): Here, $T_1 = 20^\circ\text{C}$, $T_2 = 40^\circ\text{C}$, $\rho_{20} = 998 \text{ kg m}^{-3}$, $\rho_{40} = 992 \text{ kg m}^{-3}$

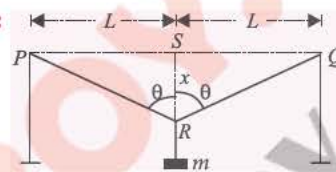
$$\text{As } \rho_{T_2} = \frac{\rho_{T_1}}{(1 + \gamma \Delta T)} = \frac{\rho_{T_1}}{1 + \gamma(T_2 - T_1)}$$

$$\therefore 992 = \frac{998}{1 + \gamma(40 - 20)} \quad \text{or } 992 = \frac{998}{1 + 20\gamma}$$

$$\text{or } 1 + 20\gamma = \frac{998}{992} \quad \text{or } 20\gamma = \frac{998}{992} - 1 = \frac{6}{992}$$

$$\text{or } \gamma = \frac{6}{992} \times \frac{1}{20} = 3 \times 10^{-4} \text{ } ^\circ\text{C}^{-1}$$

13. (a):



From the figure,

Increase in length, $\Delta L = (PR + RQ) - PQ = 2PR - PQ$

$$\Delta L = 2(L^2 + x^2)^{1/2} - 2L = 2L \left(1 + \frac{x^2}{L^2}\right)^{1/2} - 2L$$

$$= 2L \left[1 + \frac{1}{2} \frac{x^2}{L^2}\right] - 2L \quad (\text{By binomial theorem})$$

$$= \frac{x^2}{L} \quad \therefore \text{Strain} = \frac{\Delta L}{2L} = \frac{x^2}{2L^2}$$

14. (a): Let V_1 and V_2 be the volumes of two mercury droplets of radii r_1 and r_2 respectively.

$$r_1 = 0.1 \text{ cm} = 10^{-3} \text{ m}, \quad r_2 = 0.2 \text{ cm} = 2 \times 10^{-3} \text{ m}$$

Surface tension, $T = 435.5 \times 10^{-3} \text{ N m}^{-1}$.

V = Volume of the resulting drop of radius r

$$V = V_1 + V_2$$

$$\text{or } \frac{4}{3} \pi r^3 = \frac{4}{3} \pi r_1^3 + \frac{4}{3} \pi r_2^3$$

$$\text{or } r^3 = r_1^3 + r_2^3 = (10^{-3})^3 + (2 \times 10^{-3})^3 = 9 \times 10^{-9}$$

$$\text{or } r = 2.08 \times 10^{-3} \text{ m} \approx 2.1 \times 10^{-3} \text{ m}$$

$$\text{Decrease in surface area, } \Delta A = 4\pi[(r_1^2 + r_2^2) - r^2]$$

$$\text{or } \Delta A = 4 \times 3.14 [10^{-6} + 4 \times 10^{-6} - 4.41 \times 10^{-6}]$$

$$\text{or } \Delta A = 7.4 \times 10^{-6} \text{ m}^2$$

Energy released, $E = T \times \Delta A$

$$= 435.5 \times 10^{-3} \times 7.4 \times 10^{-6} = 32 \times 10^{-7} \text{ J}$$

15. (b): Here, mass of copper block, $m_1 = 2.5 \text{ kg}$

Specific heat of copper,

$$s = 0.39 \text{ J g}^{-1} \text{ } ^\circ\text{C}^{-1} = 0.39 \times 10^3 \text{ J kg}^{-1} \text{ } ^\circ\text{C}^{-1}$$

Temperature of furnace, $\Delta T = 500^\circ\text{C}$

Latent heat of fusion,

$$L = 335 \text{ J g}^{-1} = 335 \times 10^3 \text{ J kg}^{-1}$$

If Q be the heat absorbed by the copper block, then

$$Q = m_1 s \Delta T \quad \dots(i)$$

Let m_2 (kg) be the mass of ice melted when copper block is placed on it, then

$$Q = m_2 L \quad \dots(ii)$$

From eqns. (i) and (ii), we get

$$m_1 s \Delta T = m_2 L$$

$$\text{or } m_2 = \frac{m_1 s \Delta T}{L}$$

$$\text{or } m_2 = \frac{2.5 \times 0.39 \times 10^3 \times 500}{335 \times 10^3} = 1.455 \text{ kg} = 1.5 \text{ kg}$$

16. (a): Here, $\gamma = 49 \times 10^{-5} \text{ }^\circ\text{C}^{-1}$, $\Delta T = 30^\circ\text{C}$

Let there be m grams of glycerine and its initial volume be V . Suppose that the volume of the glycerine becomes V' after a rise of temperature of 30°C then,

$$V' = V(1 + \gamma \Delta T) = V(1 + 49 \times 10^{-5} \times 30)$$

$$\text{or } V' = 1.0147 V$$

Initial density of the glycerine, $\rho = \frac{m}{V}$

Final density of the glycerine,

$$\rho' = \frac{m}{V'} = \frac{m}{1.0147V} = \frac{\rho}{1.0147} = 0.9855 \rho$$

Therefore, fractional change in the value of density of glycerine,

$$\frac{\rho - \rho'}{\rho} = \frac{\rho - 0.9855 \rho}{\rho} = 0.0145$$

17. (c): Efficiency η of a Carnot engine is given by

$$\eta = 1 - \frac{T_2}{T_1}, \text{ where } T_1 \text{ is the temperature of the source and } T_2 \text{ is the temperature of the sink.}$$

Here, $T_2 = 500 \text{ K}$

$$\therefore 0.5 = 1 - \frac{500}{T_1} \text{ or } T_1 = 1000 \text{ K}$$

$$\text{Now, } 0.6 = 1 - \frac{T_2'}{1000}$$

(T_2' is the new sink temperature)

$$\text{or } T_2' = 400 \text{ K}$$

18. (d): Ideal gas equation, for an adiabatic process is

$$PV^\gamma = \text{constant or } P_1 V_1^\gamma = P_2 V_2^\gamma$$

For monatomic gas $\gamma = \frac{5}{3}$

$$\therefore P_1 V_1^{5/3} = P_2 \left(\frac{V_1}{8}\right)^{5/3}$$

$$\Rightarrow P_2 = P_1 \times (2)^5 = 32P_1$$

19. (b): Here, $450 = 400 \left(\frac{340 + v_s}{340 - v_s}\right)$

$$\text{or } \frac{9}{8} = \frac{340 + v_s}{340 - v_s}$$

$$\text{or } 9(340) - 9v_s = 8(340) + 8v_s$$

$$\text{or } 17v_s = 340 \text{ or } v_s = 20 \text{ m s}^{-1}$$

20. (b): $(v_{\text{approach}})_A = 5.5 = \left(\frac{v + v_A}{v}\right)5$

$$(v_{\text{approach}})_B = 6 = \left(\frac{v + v_B}{v}\right)5$$

Where v is the velocity of sound.

$$\text{Now, } 5.5 = \left(1 + \frac{v_A}{v}\right)5 \Rightarrow \frac{v_A}{v} = 0.1$$

$$\text{Similarly, } 6 = \left(1 + \frac{v_B}{v}\right)5 \Rightarrow \frac{v_B}{v} = \frac{1}{5}$$

$$\therefore \frac{v_B}{v_A} = 2$$

21. (d): $\frac{1}{2} m v_{\text{max}}^2 = 9 \text{ J} - 5 \text{ J} = 4 \text{ J}$

$$\text{or } m v_{\text{max}}^2 = 8 \text{ or } 2v_{\text{max}}^2 = 8 \Rightarrow v_{\text{max}} = 2 \text{ m s}^{-1}$$

$$\therefore v_{\text{max}} = 2 \text{ m s}^{-1} = A\omega$$

$$\therefore \omega = \frac{v_{\text{max}}}{A} = \frac{2}{0.01} = 200 \text{ rad s}^{-1}$$

$$\text{or } \frac{2\pi}{T} = 200$$

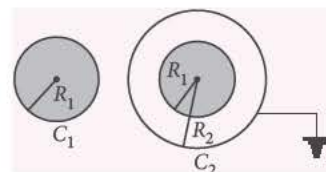
$$\text{or } T = \frac{2\pi}{200} = \frac{\pi}{100} \text{ s}$$

22. (d)

23. (a): From the figure $C_1 = 4\pi\epsilon_0 R_1$

$$C_2 = 4\pi\epsilon_0 \left(\frac{R_1 R_2}{R_2 - R_1}\right)$$

$$\text{As } C_2 = nC_1$$



$$\therefore \frac{4\pi\epsilon_0 R_1 R_2}{R_2 - R_1} = n4\pi\epsilon_0 R_1$$

$$\text{or } \frac{R_2}{R_2 - R_1} = n \text{ or } R_2(n - 1) = R_1 n$$

$$\therefore \frac{R_2}{R_1} = \frac{n}{n - 1}$$

24. (a): Here, $F = 40 = \frac{k(3)(8)}{r^2}$

$$F' = \frac{k(3-5)(8-5)}{r^2} = \frac{-6k}{r^2}$$

$$\frac{F'}{F} = -\frac{1}{4}; F' = -\frac{F}{4} = -\frac{40}{4} = -10 \text{ N}$$

25. (d): $I = \frac{\epsilon}{R + r}$

$$\text{or } IR + Ir = \epsilon$$

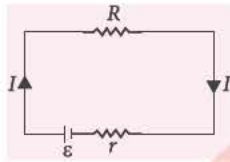
$$\text{Here, } R = 10 \Omega, r = ?,$$

$$\epsilon = 2.1 \text{ V}, I = 0.2 \text{ A}$$

$$\therefore 0.2 \times 10 + 0.2 \times r = 2.1$$

$$2 + 0.2r = 2.1$$

$$0.2r = 0.1 \text{ or } r = \frac{1}{2} = 0.5 \Omega$$



26. (b): Resistance of a wire,

$$R = \rho \frac{l}{A} = 4 \Omega \quad \dots(i)$$

When wire is stretched twice, its new length will be l' . Then $l' = 2l$

$\therefore lA = l'A'$ where A' is the new cross sectional area

$$\text{or } A' = \frac{l}{l'} A = \frac{l}{2l} A = \frac{A}{2}$$

\therefore Resistance of the stretched wire is

$$R' = \rho \frac{l'}{A'} = \rho \frac{2l}{(A/2)} = 4\rho \frac{l}{A} = 4(4 \Omega) = 16 \Omega \quad (\text{Using eqn. (i)})$$

27. (d): If d_1 is distance of point X on axial line and d_2 is distance of point Y on equatorial line

$$\text{then } B_1 = \frac{\mu_0}{4\pi} \frac{2M}{d_1^3}, \quad B_2 = \frac{\mu_0}{4\pi} \frac{M}{d_2^3}$$

$$\text{As } B_1 = B_2 \therefore \frac{\mu_0}{4\pi} \frac{2M}{d_1^3} = \frac{\mu_0}{4\pi} \frac{M}{d_2^3}$$

$$\text{or } d_1^3 = 2d_2^3 \text{ or } \frac{d_1}{d_2} = 2^{1/3}$$

28. (a): In a magnetic field,

$$\frac{mv^2}{r} = Bqv \text{ or } r = \frac{mv}{Bq} \text{ and } K = \frac{1}{2} mv^2$$

$$mv = \sqrt{2mK} \text{ so } r = \frac{\sqrt{2mK}}{Bq} \Rightarrow r \propto \frac{\sqrt{m}}{q}$$

For same values of K and B

$$r_p : r_d : r_\alpha = \frac{\sqrt{m_p}}{q_p} : \frac{\sqrt{m_d}}{q_d} : \frac{\sqrt{m_\alpha}}{q_\alpha}$$

$$= \frac{\sqrt{m}}{e} : \frac{\sqrt{2m}}{e} : \frac{\sqrt{4m}}{2e} = 1 : \sqrt{2} : 1$$

29. (b)

30. (b): Here, $B = 0.02 \text{ T}, \frac{dr}{dt} = 1 \text{ mm s}^{-1} = 10^{-3} \text{ m s}^{-1}$

$$r = 4 \text{ cm} = 4 \times 10^{-2} \text{ m}, \epsilon = ?$$

$$\therefore \phi = BA = B(\pi r^2)$$

$$\therefore \epsilon = \frac{d\phi}{dt} = \frac{d}{dt} (B\pi r^2) = B\pi 2r \frac{dr}{dt}$$

$$= 0.02 \times \frac{22}{7} \times 2 \times 4 \times 10^{-2} \times 10^{-3}$$

$$= 5 \times 10^{-6} \text{ V} = 5 \mu\text{V}$$

31. (b): Here, $R = 30 \Omega, X_L = 10 \Omega, X_C = 10 \Omega$

$$\epsilon = 300\sqrt{2} \sin \omega t, \epsilon_0 = 300\sqrt{2} \text{ V}$$

$$I = \frac{\epsilon_{rms}}{Z} = \frac{\epsilon_0 / \sqrt{2}}{\sqrt{R^2 + (X_L - X_C)^2}} = \frac{300}{\sqrt{30^2 + (10 - 10)^2}}$$

$$I = 10 \text{ A}$$

32. (a)

33. (b): Here, $B_0 = 200 \mu\text{T} = 200 \times 10^{-6} \text{ T} = 2 \times 10^{-4} \text{ T}$

In electromagnetic wave, average energy density corresponding to electric field is equal to average energy density corresponding to magnetic field, i.e.,

$$u_{av} = \frac{1}{4} \epsilon_0 E_0^2 = \frac{1}{4} \frac{B_0^2}{\mu_0}$$

$$= \frac{(2 \times 10^{-4})^2}{4 \times (4\pi \times 10^{-7})} = 8 \times 10^{-3} \text{ J m}^{-3}$$

34. (a): Here, $\mu_1 = 1, \mu_2 = 1.5, u = -100 \text{ cm}$

$$R = +20 \text{ cm},$$

[R is +ve for a convex refracting surface]

JEE

PRACTICE PAPER 2017 ADVANCED

Exam on
21st May

PAPER-I

SECTION 1 (Maximum Marks : 15)

- This section contains FIVE questions.
- Each question has FOUR options (a), (b), (c) and (d). ONLY ONE of these four options is correct.
- For each question, darken the bubble corresponding to the correct option in the ORS.
- For each question, marks will be awarded in one of the following categories :

Full Marks : +3 If only the bubble corresponding to the correct option is darkened.

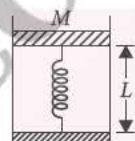
Zero Marks : 0 If none of the bubbles is darkened.

Negative Marks : -1 In all other cases.

1. A parallel plate air capacitor is connected to a battery. The quantities charge, voltage, electric field and energy associated with this capacitor are given by Q_0 , V_0 , E_0 and U_0 respectively. A dielectric slab is now introduced to fill the space between the plates with battery still in connection. The corresponding quantities now given by Q , V , E and U are related to the previous one as

- (a) $Q > Q_0$ (b) $V > V_0$
(c) $E > E_0$ (d) $U = U_0$

2. A heavy container containing an ideal gas is kept on a horizontal surface. A smooth piston of mass M is at rest as shown in the figure. The natural length of the spring is L . Now the piston is given a small downward push. Assuming the temperature of the gas to be constant, and there is vacuum over the piston, the time period for small oscillations is



- (a) $2\pi\sqrt{\frac{M}{k}}$ (b) $2\pi\sqrt{\frac{L}{g}}$
(c) $2\pi\sqrt{\frac{ML}{Mg + kL}}$ (d) None of these

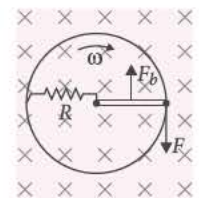
3. If a planet revolving around the Sun with time period T , is suddenly stopped in its orbit supposed to be circular.

It would fall onto the Sun in a time

- (a) $t = \left(\frac{2}{7}\right)T$ (b) $t = \left(\frac{\sqrt{2}}{8}\right)T$
(c) $t = \left(\frac{2\pi}{7}\right)T$ (d) $t = \left(\frac{\pi}{2}\right)T$

4. A metallic ring of radius r with a uniform metallic spoke of negligible mass and length r is rotated about its axis with angular velocity ω in a perpendicular uniform magnetic field B as shown in figure. The central end of the spoke is connected to the rim of the wheel through a resistor R as shown. The resistor does not rotate, its one end is always at the center of the ring and the other end is always in contact with the ring. A force F as shown is needed to maintain constant angular velocity of the wheel. F is equal to (the ring and the spoke has zero resistance)

- (a) $\frac{B^2\omega r^2}{8R}$ (b) $\frac{B^2\omega r^2}{2R}$
(c) $\frac{B^2\omega r^3}{2R}$ (d) $\frac{B^2\omega r^3}{4R}$



5. Find the pressure at which temperature attains its maximum value if the relation between pressure and volume for an ideal gas is $P = P_0 + (1 - \alpha)V^2$; $\alpha > 1$

- (a) $\frac{2P_0}{3}$ (b) $\frac{P_0}{3}$ (c) P_0 (d) $\frac{4P_0}{3}$

SECTION 2 (Maximum Marks : 32)

- This section contains EIGHT questions.
- Each question has FOUR options (a), (b), (c) and (d). ONE OR MORE THAN ONE of these four option(s) is(are) correct.
- For each question, darken the bubble(s) corresponding to all the correct option(s) in the ORS.
- For each question, marks will be awarded in one of the following categories :

Full Marks : +4 If only the bubble(s) corresponding to the correct option(s) is(are) darkened.

Partial Marks : +1 For darkening a bubble corresponding to each correct option, provided NO incorrect option is darkened.

Zero Marks : 0 If none of the bubbles is darkened.

Negative Marks : -2 In all other cases.

- For example, if (a), (c) and (d) are all the correct options for a question, darkening all these three will result in +4 marks; darkening only (a) and (d) will result in +2 marks; and darkening (a) and (b) will result in -2 marks, as a wrong option is also darkened.

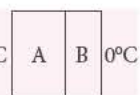
6. If P , Q , R are physical quantities, having different dimensions, which of the following combinations can never be a meaningful quantity?

- (a) $(P - Q)/R$ (b) $PQ - R$
 (c) $(R + Q)/P$ (d) $(PR - Q^2)/R$

7. Mercury of density (ρ_{Hg}) is poured into cylindrical communicating vessels of cross-sectional area A_1 and A_2 ($A_1 > A_2$). A solid iron cube of volume V_0 and density ρ_{iron} is dropped into the broad vessel, and as a result the level of the mercury in it rises. Then liquid of density ρ_{liq} poured into the broader vessel until the mercury reaches the previous level in it. The height of liquid column h is

- (a) $\frac{V_0 \rho_{\text{iron}}}{\rho_{\text{liq}} (A_2 + V_0^{2/3})}$ if the liquid does not submerge the block
 (b) $\frac{V_0 \rho_{\text{iron}}}{\rho_{\text{liq}} A_2}$ if the liquid does not submerge the block
 (c) $\frac{V_0}{A_2}$ if the liquid submerge the block
 (d) $\frac{V_0 \left(\frac{\rho_{\text{iron}} - \rho_{\text{liq}}}{\rho_{\text{Hg}} - \rho_{\text{liq}}} \right) \rho_{\text{Hg}}}{A_2 \left(\frac{\rho_{\text{iron}} - \rho_{\text{liq}}}{\rho_{\text{Hg}} - \rho_{\text{liq}}} \right) \rho_{\text{liq}}}$ if the liquid submerge the block

8. Two parallel plates A and B are joined together to form a compound plate as shown in figure. The thicknesses of the plates are 4.0 cm and 2.5 cm respectively and the area of cross section is 100 cm² for each plate. The thermal conductivities are $K_A = 200 \text{ W m}^{-1}\text{C}^{-1}$ for the plate A and $K_B = 400 \text{ W m}^{-1}\text{C}^{-1}$ for the plate B . The outer surface of the plate A is maintained at 100°C and the outer surface of the plate B is maintained at 0°C.



- (a) the rate of heat flow through any cross section is 3810 W.

- (b) the temperature at the interface is 24°C

- (c) the equivalent thermal conductivity of the compound plate is $548 \text{ W m}^{-1}\text{C}^{-1}$

- (d) ratio of thermal resistance of plate A to the equivalent thermal resistance is 0.76.

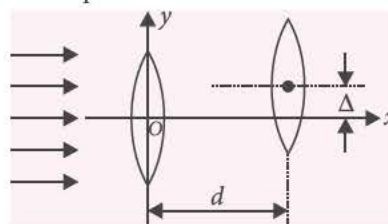
9. Two rays of light A and B with wavelength 5000 Å travel parallel to each other in air. Ray A encounters a 1 mm thick layer of glass with refractive index $\mu = 1.5$. Then,

- (a) ray B will complete more oscillation than ray A
 (b) both rays will complete same number of oscillations
 (c) ray A will complete more oscillations than ray B
 (d) the actual difference in number of oscillation made by two waves over the 1 mm distance is 1000.

10. An external magnetic field is decreased to zero, due to which a current is induced in a circular wire loop of radius r and resistance R placed in the field. This current will not become zero,

- (a) at the instant when external magnetic field stops changing ($t = 0$), the current in the loop as a function of time for $t > 0$ is given by $i_0 e^{-2Rt/\mu_0 \pi r}$
 (b) at the instant when B stops changing ($t = 0$), the current in the loop as a function of time $t > 0$ is given by $\frac{\mu_0 IR}{2r}$
 (c) the time in which current in loop decreases to $10^{-3} I_0$ (from $t = 0$) for $R = 100 \Omega$ and $r = 5 \text{ cm}$ is given by $\frac{3\pi^2 \ln 10}{10^{10}} \text{ s}$
 (d) the time in which current in loop decreases to $10^{-3} I_0$ (from $t = 0$) for $R = 100 \Omega$ and $r = 5 \text{ cm}$ is given by $\frac{3\pi^2}{10^6} \text{ s}$

11. Two thin convex lenses of focal lengths f_1 and f_2 are separated by a horizontal distance d (where $d < f_1$, $d < f_2$) and their centres are displaced by a vertical separation Δ as shown in the figure.

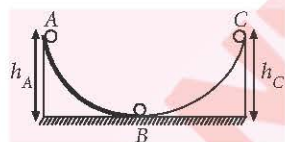


Taking the origin of coordinates O , at the centre of the first lens, the x and y coordinates of the focal point of this lens system, for a parallel beam of rays coming from the left, are given by

- (a) $x = \frac{f_1 f_2}{f_1 + f_2}, y = \Delta$
 (b) $x = \frac{f_1(f_1 + d)}{f_1 + f_2 - d}, y = \frac{\Delta}{f_1 + f_2}$
 (c) $x = \frac{f_1 f_2 + d(f_1 - d)}{f_1 + f_2 - d}, y = \frac{\Delta(f_1 - d)}{f_1 + f_2 - d}$
 (d) $x = \frac{f_1 f_2 + d(f_1 - d)}{f_1 + f_2 - d}, y = 0$.

12. A small ball starts moving from A over a fixed track as shown in the figure. Surface AB has friction. From A to B the ball rolls without slipping. Surface BC is frictionless. K_A, K_B and K_C are kinetic energies of the ball at A, B and C respectively. Then

- (a) $h_A > h_C; K_B > K_C$
 (b) $h_A > h_C; K_C > K_A$
 (c) $h_A = h_C; K_B = K_C$
 (d) $h_A < h_C; K_B > K_C$



13. In the arrangement shown in figure, gas is thermally insulated. An ideal gas is filled in the cylinder having pressure P_0 ($>$ atmospheric pressure P_a). Spring of force constant k is initially unstretched. Piston of mass m and area S is frictionless. In equilibrium piston rises up a distance x_0 , then



- (a) Final pressure of the gas is $P_a + \frac{kx_0}{S} + \frac{mg}{S}$
 (b) Work done by the gas is $\frac{1}{2}kx_0^2 + mgx_0$
 (c) Decrease in internal energy of the gas is $\frac{1}{2}kx_0^2 + mgx_0 + P_a Sx_0$
 (d) Work done by the gas is $\frac{12}{2}kx_0^2$

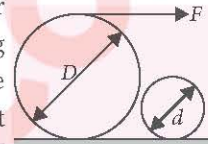
SECTION 3 (Maximum Marks : 15)

- This section contains FIVE questions.
- The answer to each question is a SINGLE DIGIT INTEGER ranging from 0 to 9, both inclusive.
- For each question, darken the bubble corresponding to the correct integer in the ORS.
- For each question, marks will be awarded in one of the following categories :

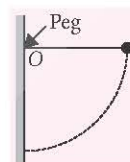
Full Marks : +3 If only the bubble corresponding to the correct answer is darkened.

Zero Marks : 0 In all other cases.

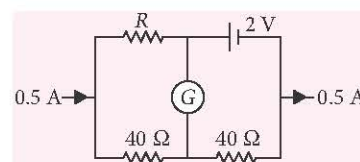
14. Two cylindrical rollers of diameters D and d respectively rest on a horizontal plane as shown in figure. The diameter of the larger roller is four times that of smaller one. The larger roller wound round with a string is pulled with a horizontal force F . Assuming that the coefficient of friction is μ for all surfaces of contact, find the larger value of μ (in 10^{-1}) as the larger roller can be pulled over the smaller one.



15. A simple pendulum is suspended from a peg on a vertical wall. The pendulum is pulled away from the wall to a horizontal position and released. The bob hits the wall, the restitution coefficient being $2/\sqrt{5}$. What is the minimum number of impacts with the wall after which the maximum angular displacement becomes less than 60° ?



16. In the circuit shown in figure, the internal resistance of the cell is negligible. For the value of $R = (40/x) \Omega$, no current flows through the galvanometer. Find x .



17. A column of mercury of length 10 cm is contained in the middle of a horizontal tube of length 1 m which is closed at both the ends. The two equal lengths contain air at standard atmospheric pressure of 76 cm of mercury. The tube is now turned to vertical position. Then the column of mercury will be displaced by x cm. The value of x is
18. Two identical small equally charged conducting balls are suspended from long threads secured at one point. The charges and masses of the balls are such that they are in equilibrium when the distance between them is a (the length of the thread $L \gg a$). One of the balls is then discharged. Again for the certain value of distance b ($b \ll L$) between the balls, the equilibrium is restored, the value of (a^3/b^3)