PREFACE

This book contains the Daily Practice Problems (DPPs) designed for the aspirants JEE(Main+Advanced). It is a collection of problems (Physics, Chemistry & Mathematics in separate booklets) from multiple topics to understand the application of concepts learned in theory. Each DPP is kind of a timed test with marking scheme and prescribed time to be spent on each problem. It is according to the latest pattern of JEE(Advanced) and serves as a great tool for the students to simulate examination conditions at home. It enables a student to practice time management while solving a problem which helps him/her to better prepare for the target exam.

Every effort has been taken to keep this book error free, however any suggestions to improve are welcome at ***smdd@resonance.ac.in.***

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DPP

DAILY PRACTICE PROBLEMS

PHYSICS

TARGET: JEE (Main + Advanced) 2021

COURSE : VISHESH (JD) DPPs - C1 to C31

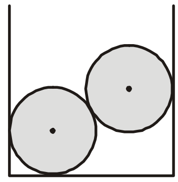
INDEX

NOTE : ✍ Marked questions are recommended for Revision.

DPP No. : C1 (JEE-Advanced)

Total Marks : 40	**Max. Time : 34 min.**
Single choice Objective ('–1' negative marking) Q.1	**(3 marks, 2 min.) [03, 03]**
One or more than one options correct type ('–1' negative marking) Q.2 to Q.3	**(4 marks 2 min.) [08, 04]**
Comprehension ('–1' negative marking) Q.4 to Q.6	**(3 marks 2 min.) [09, 06]**
Subjective Questions ('–1' negative marking) Q.7 to Q.9	**(4 marks 5 min.) [12, 15]**
Match the Following (no negative marking) Q.10	**(8 marks, 6 min.) [08, 06]**

1. Two smooth spheres each of radius 5 cm and weight W rest one on the other inside a fixed smooth cylinder of radius 8 cm. The reactions between the spheres and the vertical side of the cylinder are:

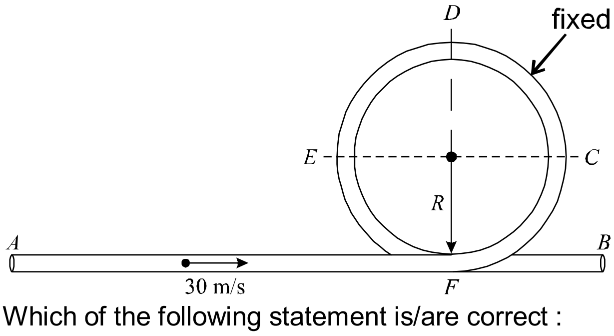


(A) W/4 & 3W/4 (B) W/4 & W/4
(C) 3W/4 & 3W/4 (D) W & W

2. A simple pendulum of length 2m with a bob of mass M oscillates with an angular amplitude of $\frac{\pi}{6}$ radians then (use $\sqrt{g} = \pi$) :
(A) tension is the string is mg cos 15º at angular displacement of 15º
(B) rate of change of speed at angular displacement of 15º is g sin 15º
(C) tension in the string is greater than mg cos 15º at angular displacement of 15º
(D) frequency of oscillation is 0.5 sec^{-1}.

3. A particle moving with kinetic energy = 3 J makes an elastic head-on collision with a stationary particle which has twice its mass. During the impact :
(A) the minimum kinetic energy of the system is 1 J
(B) the maximum elastic potential energy of the system is 2 J
(C) momentum and total energy are conserved at every instant
(D) the ratio of kinetic energy to potential energy of the system first decreases and then increases.

COMPREHENSION :
A smooth horizontal pipe is bent in the form of a vertical circle of radius 20 m as shown in figure. A small glass ball is thrown in horizontal portion of pipe at speed 30 m/s as shown from end *A*.
(Take *g* = 10 m/s^2)



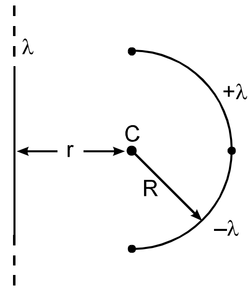
4. Which of the following statement is/are correct :
(i) ball will not come out from end *B*.
(ii) ball will come out from end *B*.
(iii) At point D speed of ball will be just more than zero.
(iv) At point E and C the ball will have same speed.
(A) only (i) (B) (ii) and (iv) (C) (ii), (iii) and (iv) (D) only (ii)

5. At what angle from vertical from bottom most point F. The normal reaction on ball due to pipe will change its direction (in terms of radially outwards and inwards) :
(A) θ = 180º (B) $\theta = \cos^{-1}\left(-\frac{2}{3}\right)$ (C) $\theta = \cos^{-1}\left(-\frac{5}{6}\right)$ (D) None of these

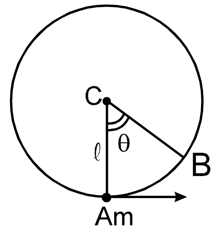
6. With what speed ball will come out from point B :

(A) 30 m/s (B) $20\sqrt{2}$ m/s (C) $10\sqrt{5}$ m/s (D) None of these

7. In the figure shown, a very long wire and a semicircular ring of radius 'R' are placed in the same plane. The centre of the ring is at a distance 'r' from the wire. The wire has uniformly distributed line charge density 'λ' and the ring has linear charge density '$+\lambda$' on one half and '$-\lambda$' on the other half as shown. Find the magnitude of net torque on the ring due to the wire.

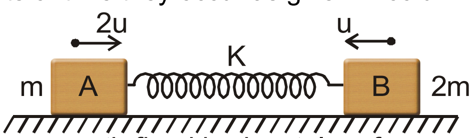


8. A particles of mass m is attached at one end of a light, inextensible string of length ℓ whose other end is fixed at the point C. The particle is given minimum velocity at the lowest point to complete the circular path in the vertical plane. As it moves in the circular path the tension in the string changes with θ. θ is defined in the figure. As θ varies from '0' to '2π' (i.e. the particle completes one revolution) plot the variation of tension 'T' against 'θ'.



9. Two particles P_1 and P_2 of equal mass situated at (0, 0) and (10, 0) respectively at t = 0 and moving with constant velocities collided head on at point (4, 0) after time t_0 . If the coefficient of restitution is 1 then what is the x-co-ordinate of centre of mass of the two particles at $t = 2t_0$.

10. Two blocks A and B of mass m and 2m connected by a light spring of spring constant k lie at rest on a fixed smooth horizontal surface. Initially the spring is unstretched. Now at time t = 0 both the blocks are imparted horizontal velocities towards each other of magnitudes 2u and u as shown in figure. In the subsequent motion, the only horizontal force acting on blocks is due to spring. Match the conditions in column-I with the instants of time they occur as given in column-II.



Column-I	Column-II
(A) The speed of both blocks are same at time	(p) $t = \frac{\pi}{2}\sqrt{\frac{2m}{3k}}$
(B) The length of spring is least at time	(q) $t = \pi\sqrt{\frac{2m}{3k}}$
(C) The length of spring is maximum at time	(r) $t = \frac{3\pi}{2}\sqrt{\frac{2m}{3k}}$
(D) The acceleration of both blocks is zero simultaneously at time	(s) $t = 2\pi\sqrt{\frac{2m}{3k}}$

DPP No. : C2 (JEE-Advanced)

Total Marks : 43		**Max. Time : 33 min.**
Single choice Objective ('–1' negative marking) Q.1	**(3 marks, 2 min.)**	**[03, 02]**
One or more than one options correct type ('–1' negative marking) Q.2 to Q.6	**(4 marks 2 min.)**	**[20, 10]**
Subjective Questions ('–1' negative marking) Q.7 to Q.9	**(4 marks 5 min.)**	**[12, 15]**
Match the Following (no negative marking) Q.10	**(8 marks, 6 min.)**	**[08, 06]**

1. A particle is revolving in a circle of radius R with initial speed v. It starts retarding with retardation $\frac{v^2}{4\pi R}$. The number of revolutions it makes in time $\frac{8\pi R}{v}$ is :

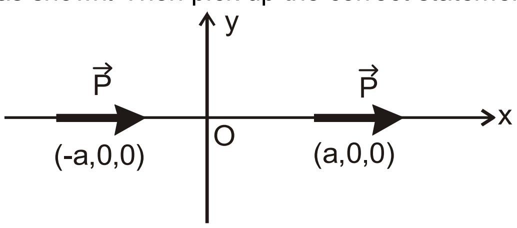
(A) 3 (B) 4 (C) 2 (D) none of these

2. A charged ring (uniform) has electric field 10 N/C at a point on the axis of it. If same charge on the same ring is distributed non–uniformly, then the electric field at the same point :

(A) must be 10 N/C (B) may be less than 10 N/C

(C) may be 10 N/C (D) may be more than 10 N/C

3. Two identical dipoles of dipole moment $\vec{P} = p_0\hat{i}$ (p_0 is a positive constant) are placed on x-axis at points A(a, 0, 0) and B(–a, 0, 0) as shown. Then pick up the correct statements :



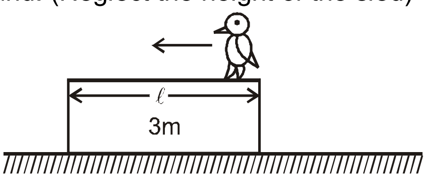
(A) The electric field at each point on y-z plane (except at infinity) must be perpendicular to y-z plane.

(B) If electric field exists at a point on y-z plane, it must be perpendicular to y-z plane.

(C) Potential at each point on y-z plane is zero.

(D) There is a circle of finite radius on y-z plane with centre at origin such that both electric field and potential are zero at each point on its periphery.

4. A penguin of mass m stands at the right edge of a sled of mass 3m and legnth . The sled lies on frictionless ice. The penguin starts moving towards left, reaches the left end and jumps with a velocity u and at an angle θ relative to ground. (Neglect the height of the sled)



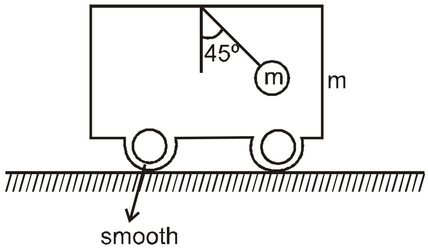
(A) Till the penguin reaches the left end, the sled is displaced by $\frac{\ell}{4}$

(B) Till the penguin reaches the left end, the sled is displaced by $\frac{\ell}{3}$

(C) After jumping, it will fall on the ground at a distance $\frac{4}{3}\frac{u^2 \sin 2\theta}{g}$ from the left end of the sled.

(D) After jumping, it will fall on the ground at a distance $\frac{3}{4}\frac{u^2 \sin 2\theta}{g}$ from the left end of the sled.

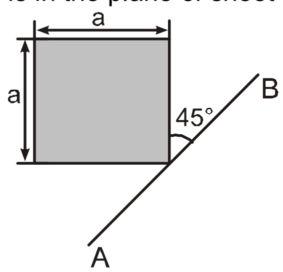
5. A cart of mass m is placed on a smooth horizontal surface. A pendulum of mass m is released from rest as shown. Then :
(A) velocity of the cart just after release is zero.
(B) acceleration of the cart just after release is g/3.
(C) velocity of the pendulum relative to the cart just after release is zero.
(D) acceleration of pendulum relative to the cart just after release is g/3.



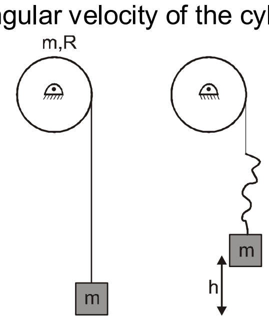
6. Consider a vernier callipers in which each 1 cm on the main scale is divided into 8 equal divisions and a screw gauge with 100 divisions on its circular scale. In the vernier callipers, 5 divisions of the vernier scale coincide with 4 division on the main scale and in the screw gauge, one complete rotation of the circular scale moves it by two divisions on the linear scale. Then,
(A) If the pitch of the screw gauge is twice the least count of the Vernier callipers, the least count of the screw gauge is 0.01mm.
(B) If the pitch of the screw gauge is twice the least count of the Vernier callipers, the least count of the screw gauge is 0.005mm.
(C) If the least count of the linear scale of the screw gauge is twice the least count of the Vernier callipers, the least count of the screw gauge is 0.01 mm.
(D) If the least count of the linear scale of the screw gauge is twice the least count of the vernier callipers, the least count of the screw gauge is 0.005 mm.

7. The energy of a system as a function of time t is given as $E(t) = A^2 \exp(-\alpha t)$, where $\alpha = 0.2 s^{-1}$. The measurement of A has an error of 1.25%. If the error in the measurement of time is 1.50%, the percentage error in the value of E(t) at t = 5 s is

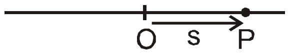
8. Find the moment of inertia (in $kg.m^2$) of a thin uniform square sheet of mass M = 3kg and side a = 2m about the axis AB which is in the plane of sheet :



9. A solid cylindrical pulley of mass m and radius R = 10 cm is hinged about its horizontal axis of symmetry. A light string is wrapped around it, and a small block of mass 'm' is suspended from the string. Now the block is lifted vertically by a distance h = 1.8 m and released. Just after the string becomes taut again, find the angular velocity of the cylinder in rad/s. (Take $g = 10 m/sec^2$)



10. A particle of mass m = 1 kg executes SHM about mean position O with angular frequency ω = 1.0 rad/s and total energy 2J. x is positive if measured towards right from O. At t = 0, particle is at O and moves towards right. Match the condition in column-I with the position of the particle in column-II

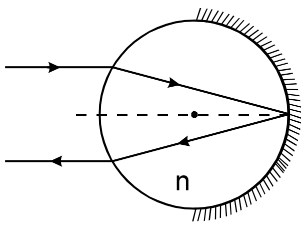


Column-I	Column-II
(A) speed of particle is $\sqrt{2}$ m/s at	(p) x = + 1m
(B) Kinetic energy of the particle is 1J at	(q) x = – 1m
(C) At t = π/6 s particle is at	(r) x = + $\sqrt{2}$ m
(D) Kinetic energy is 1.5 J at	(s) x = – $\sqrt{2}$ m

DPP No. : C3 (JEE-Advanced)

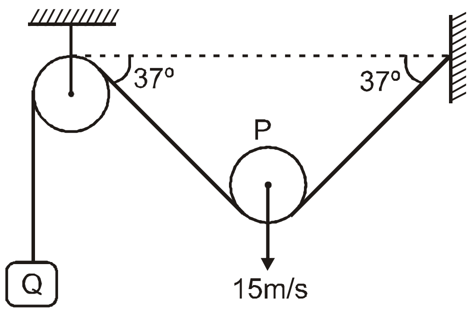
Total Marks : 37		Max. Time : 30 min.
Single choice Objective ('–1' negative marking) Q.1 to Q.2	(3 marks, 2 min.)	[06, 04]
Comprehension ('–1' negative marking) Q.3 to Q.7	(3 marks 2 min.)	[15, 10]
Subjective Questions ('–1' negative marking) Q.8 to Q.9	(4 marks 5 min.)	[08, 10]
Match the Following (no negative marking) Q.10	(8 marks, 6 min.)	[08, 06]

1. A transparent cylinder has its right half polished so as to act as a mirror. A paraxial light ray is incident from left, that is parallel to principal axis, exits parallel to the incident ray as shown. The refractive index n of the material of the cylinder is :



(A) 1.2 (B) 1.5 (C) 1.8 (D) 2.0

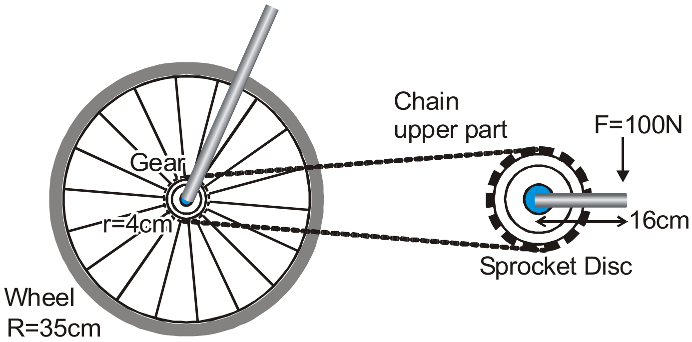
2. The massless pulley P is moving vertically downwards with constant speed of 15 m/s. Find the velocity with which the block Q moves up at the instant shown. (all pulleys are frictionless)



(A) 9 m/s (B) 12 m/s (C) 14 m/s (D) 18 m/s

COMPREHENSION

A bicycle has pedal rods of length 16 cm connected to a sprocketed disc of radius 10 cm. The bicycle wheels are 70 cm in diameter and the chain runs over a gear of radius 4 cm. The speed of the cycle is constant and the cyclist applies 100 N force that is always perpendicular to the pedal rod, as shown. Assume tension in the lower part of chain negligible. The cyclist is peddling at a constant rate of two revolutions per second. Assume that the force applied by other foot is zero when one foot is exerting 100 N force. Negelect friction within cycle parts & the rolling friction.



3. The tension in the upper portion of the chain is equal to

(A) 100 N (B) 120 N (C) 160 N (D) 240 N

4. Net torque on the rear wheel of the bicycle is equal to

(A) zero (B) 16 N-m (C) 6.4 N-m (D) 4.8 N-m

5. The power delivered by the cyclist is equal to

(A) 280 W (B) 100 W (C) 64 πW (D) 32 W

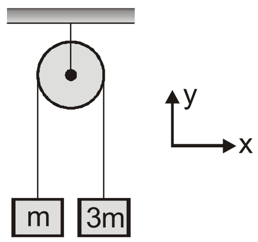
6. The speed of the bicycle is :

(A) 6.4 π m/s (B) 3.5 π m/s (C) 2.8 π m/s (D) 5.6 π m/s

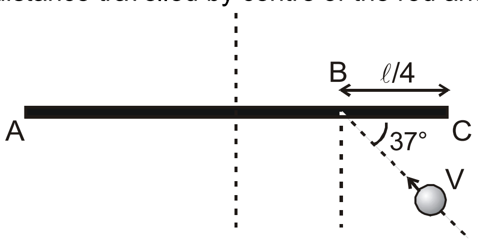
7. The net force of the friction on the rear wheel due to the road is :

(A) 100 N (B) 62 N (C) 32.6 N (D) 18.3 N

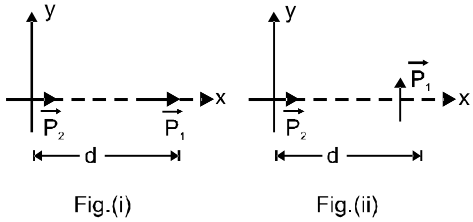
8. In the figure shown pulley and string are massless. The blocks move in vertical plane due to gravity. If the magnitude of acceleration of centre of mass of blocks is a (in m/s^2) then value of 2a is (Take g = 10 m/s^2)



9. A smooth rod AC of length ℓ and mass m is kept on a horizontal smooth plane. It is free to rotate and move. A particle of same mass m moving on the plane with velocity v strikes rod at point B making angle 37^0 with the rod. The collision is elastic. After collision, when rod move π/2 angle then (a) the angular velocity of rod, (b) distance travelled by centre of the rod and (c) impulse of the impact force.



10. Two dipoles of dipole moments $\vec{P}_1$ and $\vec{P}_2$ are oriented in two ways as shown. Assuming dipole of moment $\vec{P}_2$ to be placed at the origin and $\vec{P}_1$ at distance d from origin :

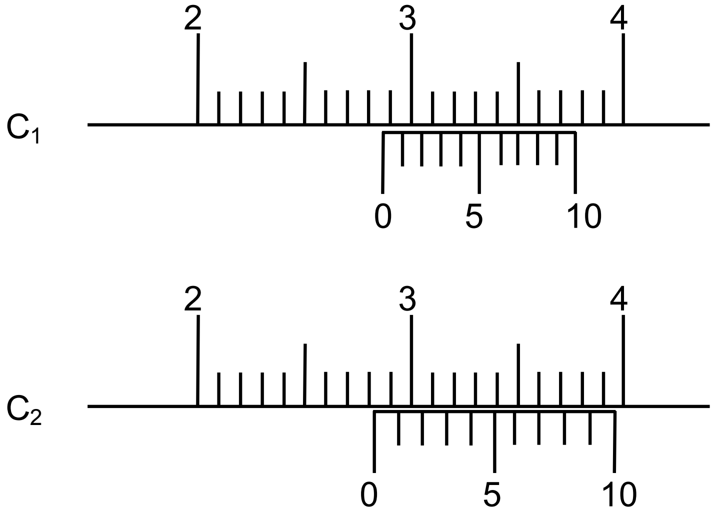


Column–I	Column–II
(A) Torque on $\vec{P}_1$ in figure–I	(p) $\frac{1}{4\pi\epsilon_0}\frac{2P_1P_2}{d^3}$
(B) Torque on $\vec{P}_1$ in figure–II	(q) $\frac{1}{4\pi\epsilon_0}\frac{P_1P_2}{d^3}$
(C) Force experienced by $\vec{P}_1$ in figure–I	(r) $\frac{1}{4\pi\epsilon_0}\frac{6P_1P_2}{d^4}$
(D) Force experienced by $\vec{P}_1$ in figure–II	(s) $\frac{1}{4\pi\epsilon_0}\frac{3P_1P_2}{d^4}$
	(t) zero

DPP No. : C4 (JEE-Advanced)

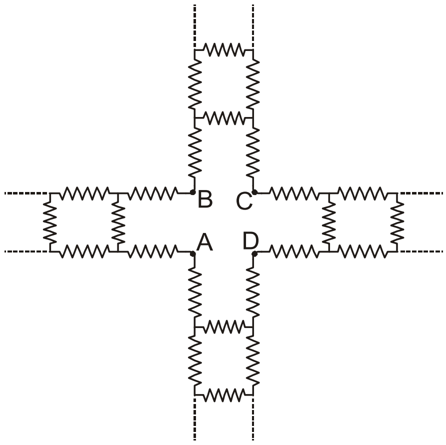
Total Marks : 40		Max. Time : 24 min.
Single choice Objective ('–1' negative marking) Q.1 to Q. 4	(3 marks, 2 min.)	[12, 08]
One or more than one options correct type ('–1' negative marking) Q.5 to Q.9	(4 marks 2 min.)	[20, 10]
Match the Following (no negative marking) Q.10	(8 marks, 6 min.)	[08, 06]

1. There are two Vernier calipers both of which have 1 cm divided into 10 equal divisions on the main scale. The Vernier scale of one of the calipers (C_1) has 10 equal divisions that correspond to 9 main scale divisions. The Vernier scale of the other caliper (C_2) has 10 equal divisions that correspond to 11 main scale divisions. The readings of the two calipers are shown in the figure. The measured values (in cm) by calipers C_1 and C_2, respectively, are : **[JEE (Advanced) 2016; P-2, 3/62, –1]**



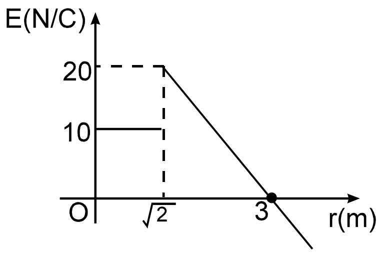
(A) 2.87 and 2.87 (B) 2.87 and 2.86 (C) 2.87 and 2.83 (D) 2.85 and 2.82

2. Four infinite ladder network containing identical resistances of RΩ each, are combined as shown in figure. The equivalent resistance between A and B is R_{AB} and between A and C is R_{AC}. Then the value of $\frac{R_{AB}}{R_{AC}}$ is :



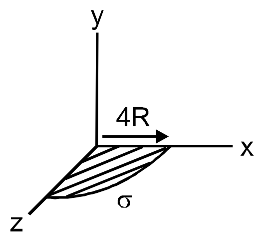
(A) $\frac{3}{4}$ (B) $\frac{4}{3}$ (C) 2 (D) $\frac{1}{2}$

3. An electric field 'E' whose direction is radially outward varies as distance from origin 'r' as shown in the graph. E is taken as positive if its direction is away from the origin. Then the work done by electric field on a 2 C charge if it is taken from (1, 1, 0) to (3, 0, 0) is :



(A) $20\,(3-\sqrt{2})$ J (B) – 60 J
(C) 60 J (D) $20\,(\sqrt{2}-3)$ J

4. Quarter non–conducting disc of radius 4R having uniform surface charge density σ is placed in xz-plane then which of the following is incorrect :



(A) electric potential at (0,3R,0) is $\frac{\sigma R}{4\epsilon_0}$

(B) electric potential at (0,0,0) is $\frac{\sigma R}{2\epsilon_0}$

(C) electric field at (0,3R,0) is symmetric with x and z axis

(D) electric field intensity at (–4R, 0, –4R) is equally inclined with x and z axis

(E) electric potential at (0,2R,0) is $\frac{\sigma R}{4\epsilon_0}$

5. A block is hanging with a light string in a lift as shown in the figure (a). The lift is moving in upward direction and its speed time graph is plotted as shown in the figure (b) : (take g = 10 m/s^2)

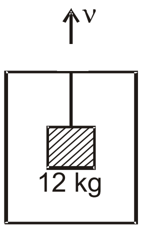


Fig.(a)

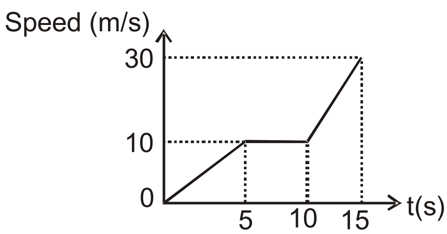
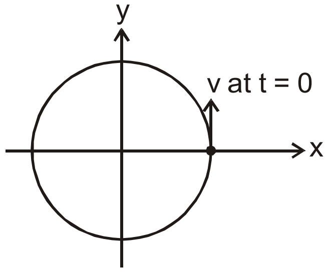


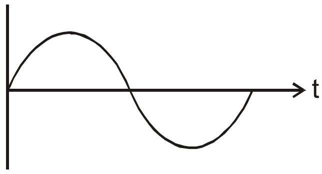
Fig.(b)

(A) Tension in the rope at t = 2 sec is 120 N (B) Tension in the rope at t = 8 sec is 120 N
(C) Tension in the rope at t = 11 sec is 168 N (D) Tension in the rope at t = 2 sec is 144 N

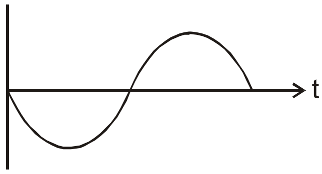
6. A particle is moving in a uniform circular motion on a horizontal surface. Particle position and velocity at time t = 0 are shown in the figure in the coordinate system. Which of the indicated variable on the vertical axis is/are correctly matched by the graph(s) shown alongside for particle's motion ?



(A) x component of velocity ⟶

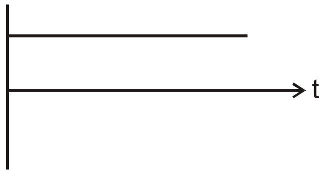


(B) y component of force keeping particle moving ⟶

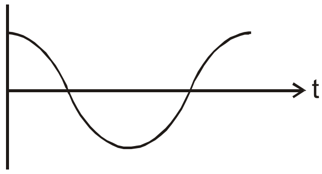


in a circle

(C) Angular velocity of the particle ⟶

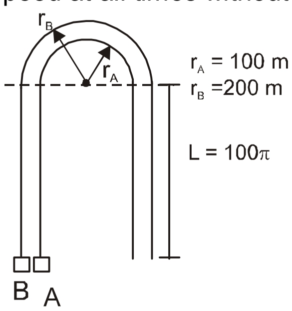


(D) x coordinate of the particle ⟶



COMPREHENSION

Two cars A and B start racing at the same time on a flat race track which consists of two straight sections each of length 100 π and one circular section as in fig. The rule of the race is that each car must travel at constant speed at all times without ever skidding. (g = 10 m/sec^2)



7. If μ_A = 0.1, μ_B = 0.2 (μ_A is coefficient of friction on track A and μ_B is the coefficient of friction on track B) then :
(A) car A completes its journey before car B
(B) both cars complete their journey in same time on circular part
(C) speed of car B is greater than that of car A
(D) car B completes its journey before cr A.

8. If speed of car A is 108 kmph and speed of car B is 180 kmph, and both tracks are equally rough :
(A) car A completes its journey before car B
(B) both cars complete their journey in same time
(C) speed of car A is greater than that of car B
(D) car B completes its journey before car A.

9. If V_B = 90kmph, the minimum value of μ_A so that car A can complete its journey before car B is :

(A) $\frac{45}{128}$ (B) $\frac{45}{100}$ (C) $\frac{45}{64}$ (D) None of these

10. Match the physical quantities given in column I with dimensions expressed in terms of mass (M), length (L), time (T) and charge (Q) given in column II and write the correct answer against the matched quantity.

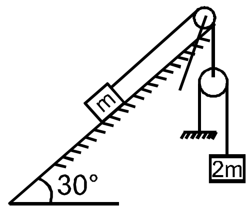
	Column I		**Column II**
(i)	Angular momentum	(a)	$ML^2 T^{-2}$
(ii)	Latent heat	(b)	$ML^2 Q^{-2}$
(iii)	Torque	(c)	$ML^2 T^{-1}$
(iv)	Capacitance	(d)	$ML^3 T^{-1} Q^{-2}$
(v)	Inductance	(e)	$M^{-1} L^{-2} T^2 Q^2$
(vi)	Resistivity	(f)	$L^2 T^{-2}$

(A) (i) - (c) (B) (ii) - (d) (C) (iii) - (e) (D) (v) - (f)

DPP No. : C5 (JEE-Main)

Total Marks : 60		**Max. Time : 40 min.**
Single choice Objective ('–1' negative marking) Q.1 to Q.20	**(3 marks, 2 min.)**	**[60, 40]**

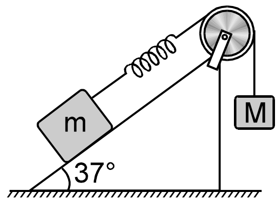
1. In the given figure inclined surface and pulleys are smooth. Strings and pulleys are massless. Acceleration of mass m is :



(A) $\frac{7g}{9}$ (B) $\frac{7g}{11}$

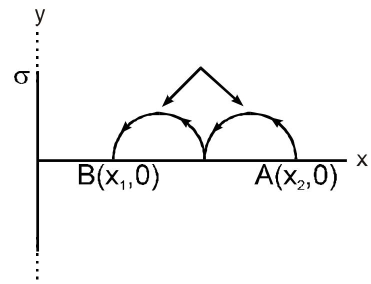
(C) $\frac{7g}{18}$ (D) $\frac{7g}{20}$

2. A block of mass m is attached with a massless spring of force constant k. The block is placed over a fixed rough inclined surface for which the coefficient of friction is $\mu = \frac{3}{4}$. The block of mass m is initially at rest. The block of mass M is released from rest with spring in undeformed state. The minimum value of M required to move the block up the plane is (neglect mass of string and pulley and friction in pulley.)



(A) $\frac{3}{5}m$ (B) $\frac{4}{5}m$ (C) $\frac{6}{5}m$ (D) $\frac{3}{2}m$

3. An infinite long plate has surface charge density σ. As shown in the fig. a point charge q is moved from A to B. Net work done by electric field is:



(A) $\frac{\sigma q}{2\epsilon_0}(x_1 - x_2)$ (B) $\frac{\sigma q}{2\epsilon_0}(x_2 - x_1)$

(C) $\frac{\sigma q}{\epsilon_0}(x_2 - x_1)$ (D) $\frac{\sigma q}{\epsilon_0}(2\pi r + r)$

4. Through an electrolyte an electric current is due to drift of:

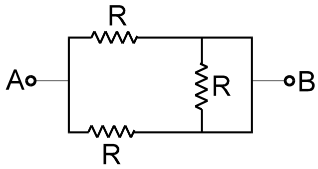
(A) free electrons (B) positive and negative ions

(C) free electrons and holes (D) protons.

5. n equal resistors are first connected in series and then connected in parallel. What is the ratio of the equivalent resistances of series to parallel combination :

(A) n (B) $\frac{1}{n^2}$ (C) n^2 (D) $\frac{1}{n}$

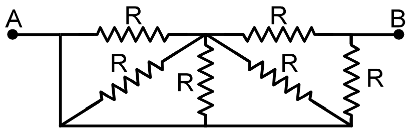
6. Equivalent resistance between A and B is :



(A) 2R (B) $\frac{R}{2}$

(C) $\frac{R}{3}$ (D) $\frac{3R}{2}$

7. The equivalent resistance between the points A and B is

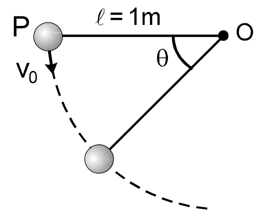


(A) $\frac{5R}{9}$ (B) $\frac{2R}{3}$ (C) R (D) None of these

8. A small toy car moves along a circle in horizontal surface. The coeficient of friction between the toy car and the horizontal surface is $\mu = \mu_0 \left(1 - \frac{r}{R}\right)$ where μ_0 & R are constant & r is radius of circle. Then radius of circle at which the toy car can move with maximum constant speed :

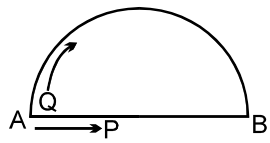
(A) $r = \frac{R}{4}$ (B) $r = \frac{R}{2}$ (C) $r = \frac{R}{3}$ (D) r = R

9. The sphere at P is given a downward velocity v_0 and swings in a vertical plane at the end of a rope of ℓ = 1m attached to a support at O. The rope breaks at angle 30° from horizontal, knowing that it can withstand a maximum tension equal to three times the weight of the sphere. Then the value of v_0 will be: ($g = \pi^2$ m/s^2)



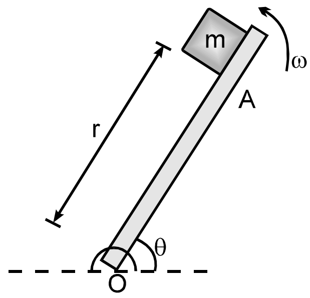
(A) $\frac{g}{2}$ m/s (B) $\frac{2g}{3}$ m/s (C) $\sqrt{\frac{3g}{2}}$ m/s (D) $\frac{g}{3}$ m/s

10. Two particles P and Q start their journey simultaneously from point A. P moves along a smooth horizontal wire AB. Q moves along a curved smooth track. Q has sufficient velocity at A to reach B always remaining in contact with the curved track. At A, the horizontal component of velocity of Q is same as the velocity of P along the wire. The plane of motion is vertical. If t_1, t_2, are times taken by P & Q respectively to reach B then (Assume velocity of P is constant)



(A) $t_1 = t_2$ (B) $t_1 > t_2$ (C) $t_1 < t_2$ (D) none of these

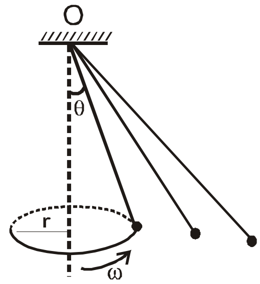
11. The member OA rotates about a horizontal axis through O with a constant counter clockwise velocity ω = 3 rad/sec. As it passes the position θ = 0, a small mass m is placed upon it at a radial distance r = 0.5 m. If the mass is observed to slip at θ = 37°, the coefficient of friction between the mass & the member is ______.



(A) $\frac{3}{16}$ (B) $\frac{9}{16}$

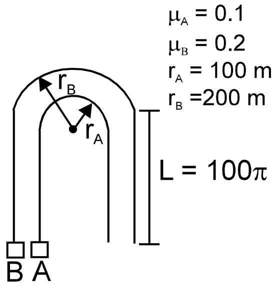
(C) $\frac{4}{9}$ (D) $\frac{5}{9}$

12. Three masses of small size are attached by light inextensible strings of various lengths to a point O on the ceiling. All of the masses swing round in horizontal circles of various radii with the same angular frequency ω (one such circle is drawn in the shown figure.) Then pick up the correct statement.



(A) The vertical depth of each mass below point of suspension from ceiling is different.
(B) The radius of horizontal circular path of each mass is same.
(C) All masses revolve in the same horizontal plane.
(D) All the particles must have same mass.

13. Two cars A and B start racing at the same time on a flat race track which consists of two straight sections each of length 100 π and one circular section as in fig. The rule of the race is that each car must travel at constant speed at all times without ever skidding

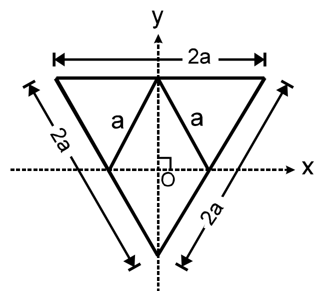


(A) car A completes its journey before car B
(B) both cars complete their journey in same time
(C) velocity of car A is greater than that of car B
(D) car B completes its journey before car A.

14. If a ball is dropped from rest, it bounces from the floor repeatedly. The coefficient of restitution is 0.5 and the speed just before the first bounce is 5ms^{-1}. The total time taken by the ball to come to rest finally is :

(A) 1.5s (B) 1s (C) 0.5s (D) 0.25s

15. The ' y ' co-ordinate of the centre of mass of the system of three rods of length '2a' and two rods of length 'a' as shown in figure is : (Assume all rods to be of uniform density)



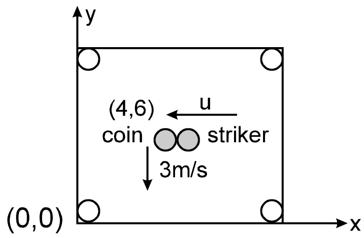
(A) $\frac{9a}{8\sqrt{3}}$ (B) $\frac{9a}{16\sqrt{3}}$

(C) zero (D) $\frac{8a}{\sqrt{3}}$

16. The centre of mass of a non uniform rod of length L whose mass per unit length λ varies as $\lambda = \frac{k \cdot x^2}{L}$ where k is a constant & x is the distance of any point on rod from its one end, is (from the same end)

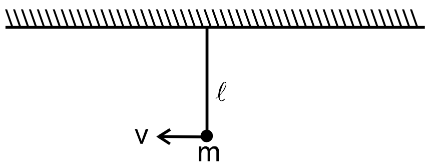
(A) $\frac{3}{4}L$ (B) $\frac{1}{4}L$ (C) $\frac{k}{L}$ (D) $\frac{3k}{L}$

17. On a smooth carom board, a coin moving in negative y–direction with a speed of 3 m/s is being hit at the point (4, 6) by a striker moving along negative x-axis. The line joining centres of the coin and the striker just before the collision is parallel to x-axis. After collision the coin goes into the hole located at the origin. Masses of the striker and the coin are equal. Considering the collision to be elastic, the initial and final speeds of the striker in m/s will be:



(A) (1.2, 0) (B) (2, 0) (C) (3, 0) (D) none of these

18. A simple pendulum of length ℓ hangs from a horizontal roof as shown in figure. The bob of mass m is given an initial horizontal velocity of magnitude $\sqrt{5g\ell}$ as shown in fig. The coefficient of restitution $e = \frac{1}{2}$. After how many collisions the bob shall no longer come into contact with the horizontal roof.

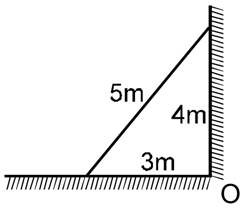


(A) 1 (B) 2 (C) 4 (D) none of these

19. A plank of mass m moving with a velocity 'v' along a frictionless horizontal track and a body of mass m/2 moving with 2v collides with plank elastically. Final speed of the plank is :

(A) $\frac{5v}{3}$ (B) v (C) $\frac{2v}{3}$ (D) none of these

20. A uniform ladder of length 5m is placed against the wall as shown in the figure. If coefficient of friction μ is the same for both the walls, what is the minimum value of μ for it not to slip?

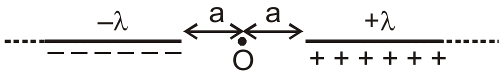


(A) μ = 1/2 (B) μ = 1/4 (C) μ = 1/3 (D) μ = 1/5

DPP No. : C6 (JEE-Advanced)

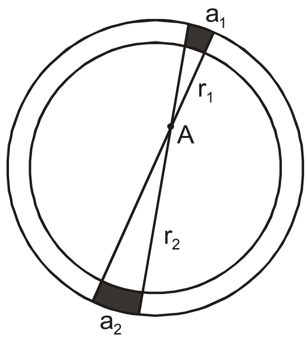
Total Marks : 40		Max. Time : 27 min.
Single choice Objective ('–1' negative marking) Q.1	(3 marks, 2 min.)	[03, 02]
Multiple choice objective ('–1' negative marking) Q.2 to Q.5	(4 marks, 2 min.)	[16, 08]
Comprehension ('–1' negative marking) Q.6 to Q.8	(3 marks 2 min.)	[09, 06]
Subjective Questions ('–1' negative marking) Q.9	(4 marks 5 min.)	[04, 05]
Match the Following (no negative marking) Q.10	(8 marks, 6 min.)	[08, 06]

1. Two very long line charges of uniform linear charge density $+\lambda$ and $-\lambda$ are placed along same line with the separation between the nearest ends being 2a, as shown in figure. The electric field intensity at point O is



(A) 0 (B) $\frac{\lambda}{\pi \in_0 a}$ (C) $\frac{\lambda}{2\pi \in_0 a}$ (D) $\frac{\lambda}{4\pi \in_0 a}$

2. A wire having a positive uniform linear charge density λ, is bent in the form of a ring of radius R. Point A as shown in the figure, is in the plane of the ring but not at the centre. Two elements of the ring of lengths a_1 and a_2 subtend very small same angle at the point A. They are at distances r_1 and r_2 from the point A respectively.

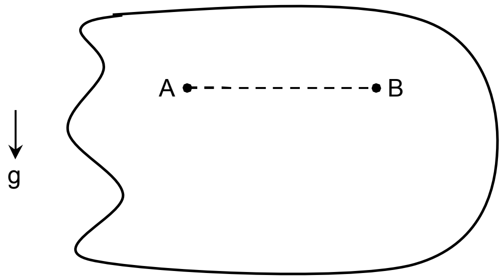


(A) The ratio of charge of elements a_1 and a_2 is r_1/r_2.
(B) The element a_1 produced greater magnitude of electric field at A than element a_2.
(C) The elements a_1 and a_2 produce same potential at A.
(D) The direction of net electric field due to a_1 and a_2 at A is towards element a_2.

3. Out of the statements given, which is/are correct ?
(A) The amplitude of a resultant simple harmonic motion obtained by superposition of two simple harmonic motions along the same direction can be less than lesser of the amplitudes of the participating SHMs.
(B) When two simple harmonic motions which are in phase and in perpendicular directions superpose then resulting motion will be SHM with same phase.
(C) When two simple harmonic motions (with amplitudes A_1 and A_2) which are out of phase (that means phase difference π) and in perpendicular directions, superpose then resulting motion will be SHM with amplitude $\sqrt{A_1^2 + A_2^2}$.
(D) The combination of two simple harmonic motions of equal amplitude in perpendicular directions differing in phase by $\pi/2$ rad is a circular motion.

4. A spring of spring constant K is fixed to the ceiling of a lift. The other end of the spring is attached to a block of mass m. The mass is in equilibrium. Now the lift accelerates downwards with an acceleration g.
(A) The block will not perform SHM and it will stick to the ceiling.
(B) The block will perform SHM with time period $2\pi\sqrt{m/K}$.
(C) The amplitude of the block will be mg/K if it perform SHM.
(D) The minimum potential energy of the spring during the motion of the block will be zero.

5. Consider a planar body of irregular size. It is kept in equilibrium in vertical plane by using 2 pins A & B lying at same vertical level as shown in figure.



Separation between A & B is d. Pins offer a small friction to the body. Normal contact offered to the body by pin A is N_A and by pin B is N_B. It is observed that when pin A is removed body rotates 150° anti-clockwise w.r.t. B and attains equilibrium. In the same manner if pin B is removed body rotates 120° clockwise w.r.t. A and attains equilibrium. Choose the correct option(s) :

(A) Value of $\frac{N_B}{N_A}$ is 3

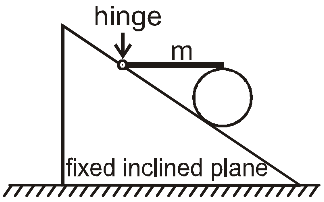
(B) Value of $\frac{N_B}{N_A}$ is 2

(C) Separation between centre of mass of body and pin A is $\frac{\sqrt{3}d}{2}$

(D) Separation between centre of mass of body and pin A is $\frac{d}{2}$

COMPREHENSION

A horizontal uniform rod of mass 'm' has its left end hinged to the fixed incline plane, while its right end rests on the top of a uniform cylinder of mass 'm' which in turn is at rest on the fixed inclined plane as shown. The coefficient of friction between the cylinder and rod, and between the cylinder and inclined plane, is sufficient to keep the cylinder at rest.



6. The magnitude of normal reaction exerted by the rod on the cylinder is :

(A) $\frac{mg}{4}$ (B) $\frac{mg}{3}$ (C) $\frac{mg}{2}$ (D) $\frac{2mg}{3}$

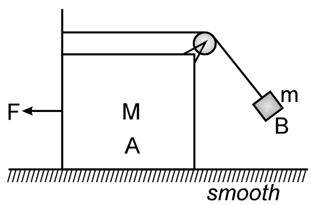
7. The ratio of magnitude of frictional force on the cylinder due to the rod and the magnitude of frictional force on the cylinder due to the inclined plane is:

(A) 1 : 1 (B) $2 : \sqrt{3}$ (C) 2 : 1 (D) $\sqrt{2} : 1$

8. The magnitude of normal reaction exerted by the inclined plane on the cylinder is:

(A) mg (B) $\frac{3mg}{2}$ (C) 2mg (D) $\frac{5mg}{4}$

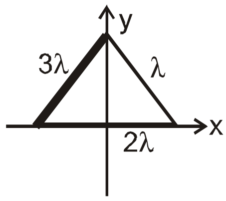
9. A force F is applied on block A of mass M so that the tension in light string also becomes F when block B of mass m acquires an equilibrium state with respect to block A. Find the force F. Give your answer in terms of m, M and g.



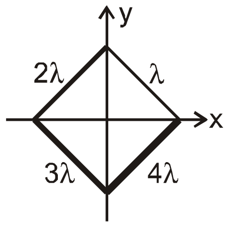
10. In each situation of column-I a mass distribution is given and information regarding x and y-coordinate of centre of mass is given in column-II. Match the figures in column-I with corresponding information of centre of mass in column-II.

Column-I

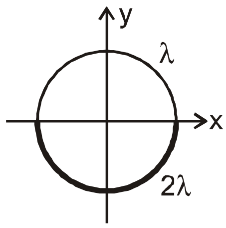
(A) An equilateral triangular wire frame is made using three thin uniform rods of mass per unit lengths λ, 2λ and 3λ as shown



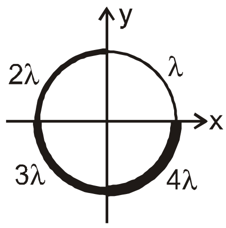
(B) A square frame is made using four thin uniform rods of mass per unit length lengths λ, 2λ, 3λ and 4λ as shown



(C) A circular wire frame is made of two uniform semicircular wires of same radius and of mass per unit length λ and 2λ as shown



(D) A circular wire frame is made of four uniform quarter circular wires of same radius and mass per unit length λ, 2λ, 3λ and 4λ as shown



Column-II

(p) $x_{cm} \geq 0$

(q) $y_{cm} \geq 0$

(r) $x_{cm} < 0$

(s) $y_{cm} < 0$

DPP No. : C7 (JEE-Advanced)

Total Marks : 39		**Max. Time : 33 min.**
Single choice Objective ('–1' negative marking) Q.1 to Q.2	**(3 marks, 2 min.)**	**[06, 04]**
One or more than one options correct type ('–1' negative marking) Q.3	**(4 marks 2 min.)**	**[04, 02]**
Comprehension ('–1' negative marking) Q.4 to Q.6	**(3 marks 2 min.)**	**[09, 06]**
Subjective Questions ('–1' negative marking) Q.7 to Q.9	**(4 marks 5 min.)**	**[12, 15]**
Match the Following (no negative marking) Q.10	**(8 marks, 6 min.)**	**[08, 06]**

1. The length of a rectangular plate is measured by a meter scale and is found to be 10.0 cm. Its width is measured by vernier callipers as 1.00 cm. The least count of the meter scale and vernier callipers are 0.1 cm and 0.01 cm respectively (Obviously). Maximum permissible error in area measurement is -
(A) + 0.2 cm^2 (B) + 0.1 cm^2 (C) + 0.3 cm^2 (D) Zero

2. In the previous question, minimum possible error in area measurement can be -
(A) + 0.02 cm^2 (B) + 0.01 cm^2 (C) + 0.03 cm^2 (D) Zero

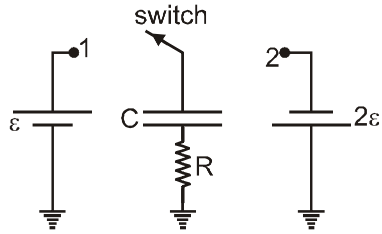
3. A positively charged particle having some mass is resting in equilibrium at a height H above the centre of a fixed, uniformly and positively charged ring of radius R. The force of gravity (mg) acts downwards. The equilibrium of the particle will be :

(A) stable If $H < \frac{R}{2}$ (B) stable If $H > \frac{R}{\sqrt{2}}$

(C) unstable If $H > \frac{R}{\sqrt{2}}$ (D) unstable If $H < \frac{R}{\sqrt{2}}$

COMPREHENSION

In the circuit arrangement shown in figure capacitor is initially uncharged. At t = 0 switch is thrown to position '1'. It remains closed till the current in the circuit becomes 50% of maximum current, then suddenly switch is shifted to position '2'. (Assume all batteries are ideal)



4. Current through the resistor just after switch is shifted to position '2' is :

(A) 0 (B) $\frac{5\varepsilon}{R}$ (C) $\frac{5\varepsilon}{2R}$ (D) $\frac{3\varepsilon}{R}$

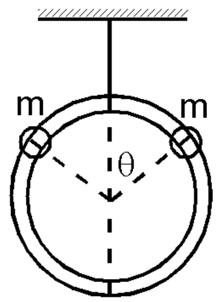
5. Amount of work done by battery long after switch is shifted to position '2' is:

(A) $\frac{5C\varepsilon^2}{2}$ (B) $\frac{C\varepsilon^2}{2}$ (C) $\frac{3C\varepsilon^2}{2}$ (D) $5C\varepsilon^2$

6. Which of the following is the correct options after switch is shifted to position '2'.

(A) Energy stored in the capacitor first increases then decreases.
(B) Energy stored in the capacitor first decreases then increases.
(C) Energy stored in the capacitor continuously decreases.
(D) Energy stored in the capacitor continuously increases.

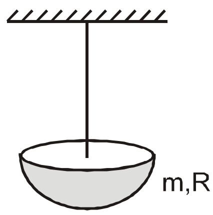
7. A massless ring hangs from a thread and two beads of mass m slide on it without friction . The beads are released simultaneously from the top of the ring and slide down along opposite sides.Find the angle from vertical at which the ring will start to rise.



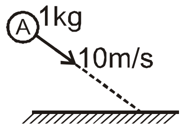
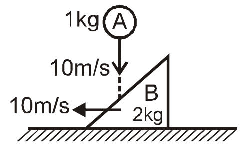
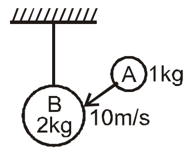
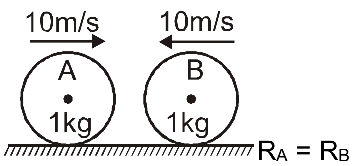
8. A billiard ball at rest is struck horizontally one tenth of the diameter below the top. If P be the impulse of the blow find the kinetic energy of the ball, just after the blow the mass of the ball is M.

9. A uniform solid hemisphere of mass m and radius R is attached to the roof with a chord of torsional constant C and performing torsional SHM. Then the time period (in seconds) of SHM is

(Take m = 15 kg, $R = \frac{2}{\pi}$ m, C = 6 Nm/rad.)



10. In column–II different situations are shown in which one object collides with the another object. In each case friction is absent and neglect effect of non–impulsive forces. In column–I different direction are given.
You have to match the directions for each case in which momentum conservation can be applied on object A or object B or system A & B.

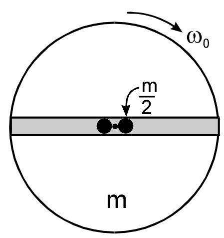
Column-I	Column-II
(A) Along the line of impact	(p) 
(B) Perpendicular to line of impact	(q) 
(C) In horizontal direction	(r) 
(D) In vertical direction	(s) 

DPP No. : C8 (JEE-Advanced)

Total Marks : 39		**Max. Time : 36 min.**
Single choice Objective ('–1' negative marking) Q.1 to Q.2	**(3 marks, 2 min.)**	**[06, 04]**
Comprehension ('–1' negative marking) Q.3 to Q.5	**(3 marks 2 min.)**	**[09, 06]**
Subjective Questions ('–1' negative marking) Q.6 to Q.9	**(4 marks 5 min.)**	**[16, 20]**
Match the Following (no negative marking) Q.10	**(8 marks, 6 min.)**	**[08, 06]**

1. A shell of mass 4 kg moving with a velocity 10 m/s vertically upward explodes into three parts at a height 50 m from ground. After three seconds, one part of mass 2 kg reaches ground and another part of mass 1 kg is at height 40 m from ground. The height of the third part from the ground is:
[$g = 10$ m/s^2]
(A) 50 m (B) 80 m (C) 100 m (D) none of these

2. A disc of mass 'm' and radius R is free to rotate in horizontal plane about a vertical smooth fixed axis passing through its centre. There is a smooth groove along the diameter of the disc and two small balls of mass $\frac{m}{2}$ each are placed in it on either side of the centre of the disc as shown in fig. The disc is given initial angular velocity ω_0 and released. The angular speed of the disc when the balls reach the end of disc is :

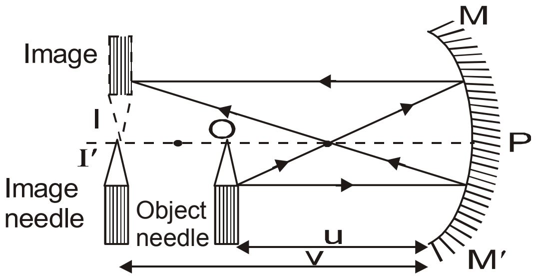


(A) $\frac{\omega_0}{2}$ (B) $\frac{\omega_0}{3}$ (C) $\frac{2\omega_0}{3}$ (D) $\frac{\omega_0}{4}$

COMPREHENSION : 2

To find focal length of a concave mirror using u-v method, for different u, we measure different v, and thus we find f using mirror's formula $\frac{1}{f}=\frac{1}{v}+\frac{1}{u}$.

In this experiment, a concave mirror is fixed at position MM' and a knitting needle is used as an object, mounted in front of the concave mirror. This needle is called object needle (O in fig)

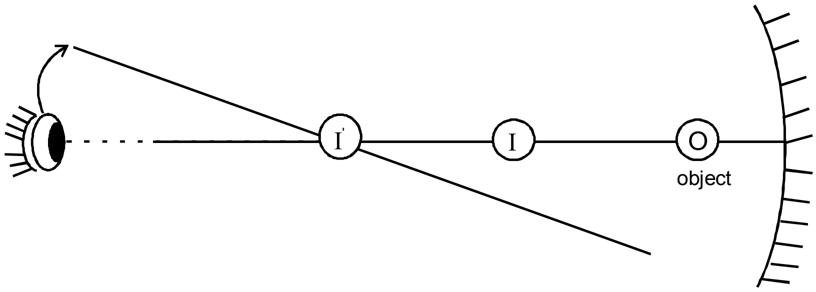


First of all we make a rough estimation of *f*. For estimating f roughly, make a sharp image of a far away object (like sun) on a filter paper. The image distance of the far object will be an approx estimation of focal length.

Now, the object needle is kept beyond f, so that its real and inverted image (I in fig) can be formed. You can see this inverted image in the mirror by closing your one eye and keeping the other eye along the pole of the mirror.

To locate the position of the image, use a second needle, and shift this needle such that its peak Coincide with the image. The second needle gives the distance of image (v), so it is called "image needle" (I' in figure). Note the object distance 'u' and image distance 'v' from the mm scale on optical bench.

Parallax: — Figure shows top view of the optical bench



Suppose image needle (I') doesn't co-insisde with image (I), the image is farther from eyes as compared to the image needle (I') as shown. If we shift our eyes to the left, the image (I), which is more distant from us, will appear to move to the left of the line of sight and if we shift our eyes to right, the image (I) will appear to move to the right of the line of sight. This shifting is called parallax. To remove this, we shift the image needle (I') towards mirror, such that it exactly co–inside with the image (I).

3. Parallax aries due to :

(A) Defect in the observers eyes

(B) The object and the image needles are not parallel

(C) Our eyes are not in the line of object and image

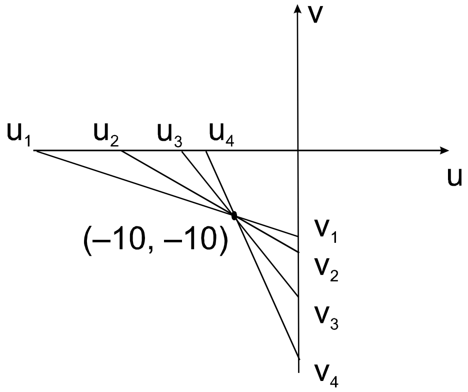
(D) The image needle is not placed exactly co-insiding the image

4. In an obseravtion, if we shift our eyes to left, the image (I) appears to move to the right of the line of sight. To find the image distance (to remove prallax) , we have to shift the image needle (I^1) :

(A) Towards the mirror (B) Away from the mirror

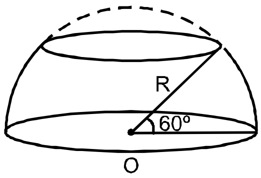
(C) Perpendicular to the principle axis (D) No need to shift

5. To find the focus distance of the concave mirror, for the different values of object distances (u_1, u_2 ... u_n), the values of image distances (v_1, v_2 ..... v_n) are measured. We mark u_1, u_2 ..... u_n on x-axis and v_1, v_2 ..... u_n on y-axis. Now draw lines joining u_1 with v_1, u_2 with u_2 .... u_n with v_n as shown in figure. The focus distance of the mirror should be

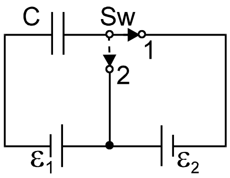


(A) 5 cm (B) 10 cm (C) 20 cm (D) 15 cm

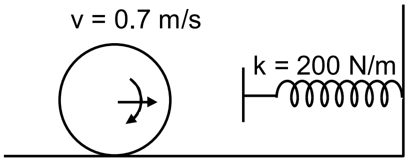
6. Figure shows the part of a hemisphere of radius (R) = 2m and surface charge density(σ) = $2\epsilon_0$ C/m^2. Calculate the electric potential (in volt) at centre O.



7. What amount of heat will be generated in the circuit shown in the figure, after the switch Sw is shifted from position 1 to position 2?



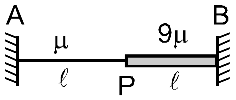
8. A uniform smooth and solid sphere of mass m = 2 kg is in pure rolling motion on smooth surface as shown velocity v of the centre is 0.7 m/s. Find maximum compression in spring in cm.



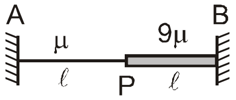
9. The speed of sound in a mixture of n_1 = 2 moles of He, n_2 = 2 moles of H_2 at temperature $T = \frac{972}{5}$ K is $\eta \times 10$ m/s. Find η. (Take $R = \frac{25}{3}$ J/mole-K)

10. Match the column :

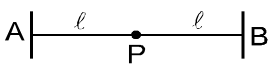
Column–I

(A) 

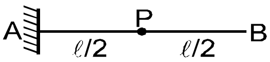
Two strings each of length ℓ and linear mass density μ and 9μ are joined together and system is oscillated such that joint P is node. T is tension in the strings. A and B are fixed ends.

(B) 

Two strings each of length ℓ and linear mass density μ and 9μ are joined together and system is oscillated such that joint P is antinode. T is tension in each string. A and B are fixed ends.

(C) 

P is the mid–point of the string fixed at both ends. T is tension in the string and μ is its linear mass density.

(D) 

T is the tension in the string fixed at A and B is free end. P is mid–point. μ is its the linear mass density.

Column–II

(p) Speed of component travelling wave is portion AP will be $\sqrt{\dfrac{T}{\mu}}$

(q) Speed of component travelling wave in the portion AP will be more than that in portion BP.

(r) Frequency of oscillation of the system AB can be $\dfrac{1}{2\ell}\sqrt{\dfrac{T}{\mu}}$

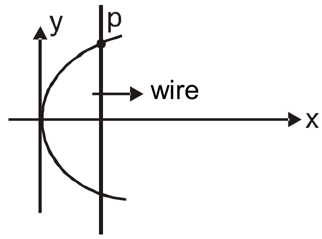
(s) Frequency of oscillation of the system AB can be $\dfrac{1}{4\ell}\sqrt{\dfrac{T}{\mu}}$

(t) Wavelength of the wave in the portion PB can be $\dfrac{2\ell}{3}$.

DPP No. : C9 (JEE-Main)

Total Marks : 57		Max. Time : 38 min.
Single choice Objective ('–1' negative marking) Q.1 to Q.19	(3 marks, 2 min.)	[57, 38]

1. A wire is bent in a parabolic shape followed by equation $x = 4y^2$. Consider origin as vertex of parabola. A wire parallel to y axis moves with constant speed 4 m/s along x-axis in the plane of bent wire. Then the acceleration of touching point of straight wire and parabolic wire is (when straight wire has x coordinate = 4 m) :

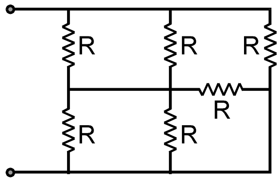


(A) $\frac{1}{2}$ (B) $\frac{1}{4}$ (C) 2 (D) 4

2. There are three concentric thin spheres of radius a, b, c (a > b > c). The total surface charge densities on their surfaces are $\sigma, -\sigma, \sigma$ respectively. The magnitude of electric field at r (distance from centre) such that a > r > b is :

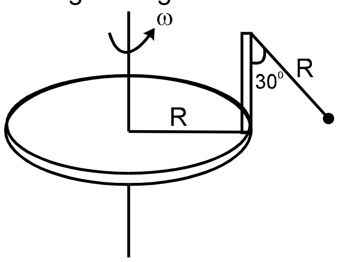
(A) 0 (B) $\frac{\sigma}{\epsilon_0 r^2}(b^2 - c^2)$ (C) $\frac{\sigma}{\epsilon_0 r^2}(a^2 + b^2)$ (D) none of these

3. The equivalent resistance of the network shown in the figure is :



(A) 3R/7 (B) 11 R/5 (C) 5 R/11 (D) none of these

4. A disc of radius R has a light pole fixed perpendicular to the disc at the circumference which in turn has a pendulum of length R attached to its other end as shown in figure. The disc is rotated with a constant angular velocity ω. The string is making an angle 30^0 with the rod. The angular velocity ω of the disc is:



(A) $\left(\frac{\sqrt{3}\,g}{R}\right)^{1/2}$ (B) $\left(\frac{\sqrt{3}\,g}{2R}\right)^{1/2}$ (C) $\left(\frac{g}{\sqrt{3}R}\right)^{1/2}$ (D) $\left(\frac{2g}{3\sqrt{3}\;R}\right)^{1/2}$

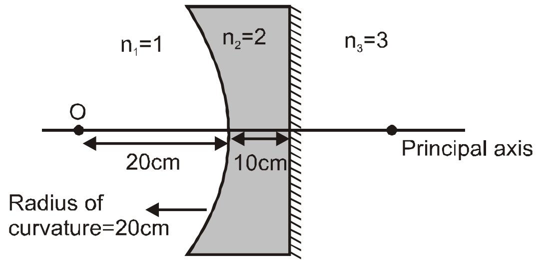
5. A particle is projected with speed 10 m/s at angle 60° with the horizontal. Then the time after which its speed becomes half of initial -

(A) $\frac{1}{2}$ sec. (B) 1 sec. (C) $\sqrt{3/2}$ sec. (D) $\sqrt{3}/2$ sec.

6. Two particles are projected horizontally and simultaneously from top of a tower in mutually perpendicular planes with same speed 30m/s. After how much time their velocity vectors will be at angle 60^o from each other.

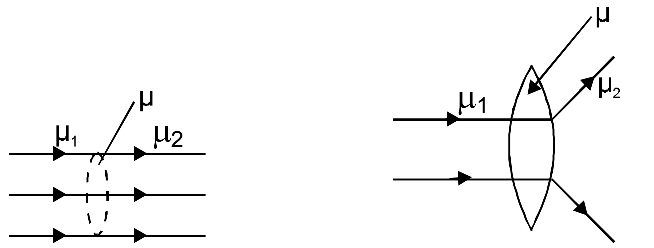
(A) 1 sec (B) 3 sec (C) 4 sec (D) 5 sec

7. Final image of point object 'O' formed by the combination is located :



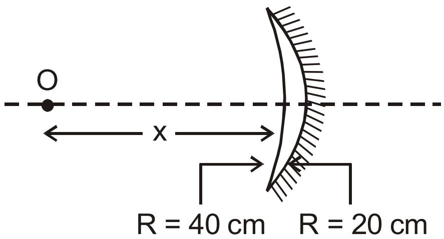
(A) On plane surface
(B) at a distance 10cm from plane surface
(C) at a distance 30cm from plane surface
(D) at a distance 20cm from curved surface
(E) at a distance 40cm from curved surface

8. The correct conclusion that can be drawn from these figures is



(A) $\mu_1 < \mu$ but $\mu < \mu_2$
(B) $\mu_1 > \mu$ but $\mu < \mu_2$
(C) $\mu_1 = \mu$ but $\mu < \mu_2$
(D) $\mu_1 = \mu$ but $\mu_2 < \mu$

9. Radii of curvature of a concavo-convex lens (refractive index = 1.5) are 40 cm (concave side) and 20 cm (convex side) as shown. The convex side is silvered. The distance x on the principal axis where an object is placed so that its image is created on the object itself, is equal to :

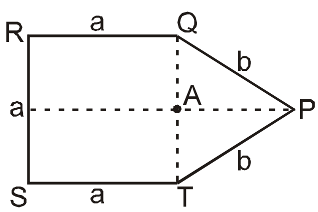


(A) 12 cm
(B) 15 cm
(C) 16 cm
(D) 24 cm

10. A ball impinges directly on a similar ball at rest. The first ball is brought to rest by the impact. If half the kinetic energy is lost by impact, what is the value of the coefficient of restitution?

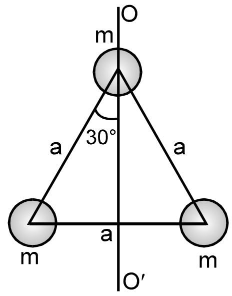
(A) $\frac{1}{2\sqrt{2}}$
(B) $\frac{1}{\sqrt{3}}$
(C) $\frac{1}{\sqrt{2}}$
(D) $\frac{\sqrt{3}}{2}$

11. A homogeneous plate PQRST is as shown in figure. The centre of mass of plate lies at midpoint A of segment QT. Then the ratio of $\frac{b}{a}$ is (PQ = PT = b; QR = RS = ST = a)



(A) $\frac{13}{4}$
(B) $\frac{13}{2}$
(C) $\sqrt{\frac{13}{2}}$
(D) $\sqrt{\frac{13}{4}}$

12. Three point masses are arranged as shown in the figure. Moment of inertia of the system about the axis O O′ is :
(passing through its plane)



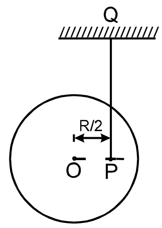
(A) 2 m a^2 (B) $\frac{ma^2}{2}$

(C) m a^2 (D) none of these

13. The moment of inertia of a door of mass m, length 2 ℓ and width ℓ about its longer side is

(A) $\frac{11\,m\ell^2}{24}$ (B) $\frac{5\,m\ell^2}{24}$ (C) $\frac{m\ell^2}{3}$ (D) none of these

14. A uniform disc of mass M and radius R is released from rest in the shown position. PQ is a string, OP is a horizontal line, O is the centre of the disc and distance OP is R/2. Then tension in the string just after the disc is released will be :



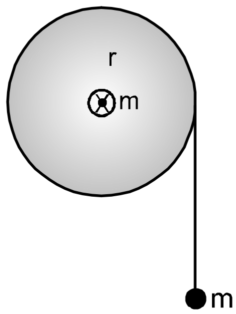
(A) $\frac{Mg}{2}$ (B) $\frac{Mg}{3}$

(C) $\frac{2Mg}{3}$ (D) none of these

15. A uniform thin rod of mass 'm' and length L is held horizontally by two vertical strings attached to the two ends. One of the string is cut. Find the angular acceleration soon after it is cut :

(A) $\frac{g}{2L}$ (B) $\frac{g}{L}$ (C) $\frac{3g}{2L}$ (D) $\frac{2g}{L}$

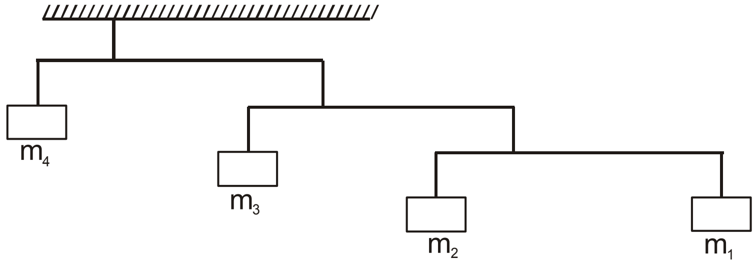
16. A uniform disc of mass m and radius r and a point mass m are arranged as shown in the figure. The acceleration of point mass is: (Assume there is no slipping between pulley and thread and the disc can rotate smoothly about a fixed horizontal axis passing through its centre and perpendicular to its plane)



(A) $\frac{g}{2}$ (B) $\frac{g}{3}$

(C) $\frac{2\,g}{3}$ (D) none of these

17. Figure shows an arrangement of masses hanging from a ceiling. In equilibrium, each rod is horizontal, has negligible mass and extends three times as far to the right of the wire supporting it as to the left. If mass m_4 is 48 kg then mass m_1 is equal to

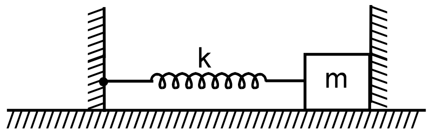


(A) 1 kg (B) 2 kg (C) 3 kg (D) 4 kg

18. A uniform rod of mass 6M and length 6l is bent to make an equilateral hexagon. Its M.I. about an axis passing through the centre of mass and perpendicular to the plane of hexagon is:

(A) $5ml^2$ (B) $6ml^2$ (C) $4ml^2$ (D) $ml^2/12$

19. A spring block system is placed on a horizontal surface so as to just fit within two vertical walls. The spring is initially unstretched. The coefficient of restitution for collison is e = $\frac{1}{2}$. The block is pulled to the left by a distance x = 1cm and released from rest. The time between second and third collision of the block with the wall is

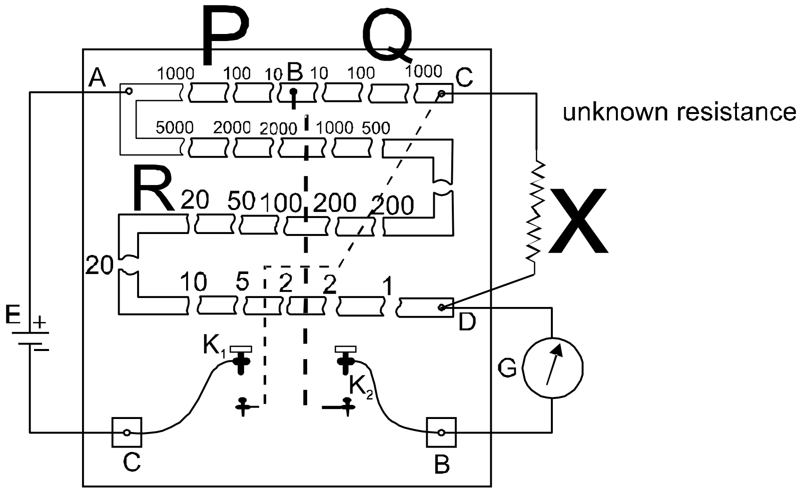


(A) $2\pi\sqrt{\frac{m}{k}}$ (B) $\pi\sqrt{\frac{m}{k}}$ (C) $\frac{\pi}{2}\sqrt{\frac{m}{k}}$ (D) $\frac{\pi}{4}\sqrt{\frac{m}{k}}$

DPP No. : C10 (JEE-Advanced)

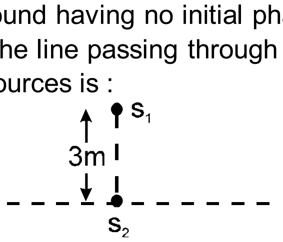
Total Marks : 42		**Max. Time : 30 min.**
Single choice Objective ('–1' negative marking) Q.1 to Q.2	**(3 marks, 2 min.)**	**[06, 04]**
One or more than one options correct type ('–1' negative marking) Q.3 to Q.7	**(4 marks 2 min.)**	**[20, 10]**
Subjective Questions ('–1' negative marking) Q.8 to Q.9	**(4 marks 5 min.)**	**[08, 10]**
Match the Following (no negative marking) Q.10	**(8 marks, 6 min.)**	**[08, 06]**

1. In the post office box circuit, 10 Ω plug is taken out in arm AB and 100 Ω plug is taken out in arm BC. If the unknown resistor is kept in melting ice chamber, 600 Ω resistance is required in arm AD for zero deflection in galvanometer. Now if the unknown resistor is kept at 100° C (steam chamber), 630 Ω resistance is required in arm AD for zero deflection. Temprature coefficient of resistance of the unknown wire is :



(A) 2.5×10^{-4} / C° (B) 5×10^{-4}/ C° (C) 7.5×10^{-4} / C° (D) 8×10^{-4} / C°

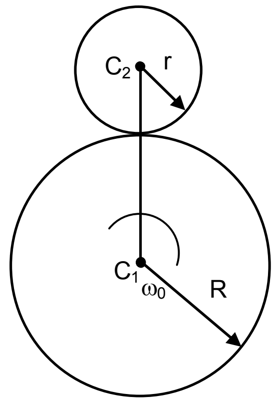
2. S_1 & S_2 are two coherent sources of sound having no initial phase difference. The velocity of sound is 330 m/s. No minima will be formed on the line passing through S_2 and perpendicular to the line joining S_1 and S_2, if the frequency of both the sources is :



(A) 50 Hz (B) 60 Hz (C) 70 Hz (D) 80 Hz

3. At displacement nodes in sound wave :
(A) Displacement amplitude is minimum
(B) Pressure amplitude is maximum
(C) Sound intensity is maximum
(D) Particle speed is minimum

4. Consider a fixed wheel of radius R. A small wheel (in the form of a uniform solid disc) of radius r is performing pure rolling on periphery of bigger wheel. Centers of bigger wheel and smaller wheel are joined by rigid rod such that smaller wheel can rotate freely w.r.t its centre. Rod joining the centers is rotating with constant angular velocity ω_0. Whole situation is shown in figure.



Choose the correct option(s) : (Use R = 4r)

(A) Angular velocity of smaller wheel is ω_0

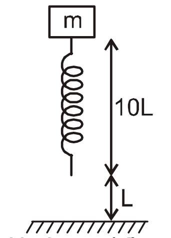
(B) Angular velocity of smaller wheel is $5\omega_0$

(C) Kinetic energy of smaller wheel is $\frac{75}{4}mr^2\omega_0^2$, where m is the mass of the smaller disc.

(D) Radius of curvature of the path of the particle which is lying on the circumference of smaller wheel and at farthest distance from centre of bigger wheel is $\frac{10r}{3}$

COMPREHENSION

A small block of mass m is fixed at upper end of a massless vertical spring of spring constant $K = \frac{4mg}{L}$ and natural length '10L'. The lower end of spring is free and is at a height L from fixed horizontal floor as shown. The spring is initially unstressed and the spring-block system is released from rest in the shown position.



5. Choose the correct option(s) :

(A) At the instant speed of block is maximum, the magnitude of force exerted by spring on the block is mg.

(B) As the block is coming down, the maximum speed attained by the block is $\frac{3}{2}\sqrt{gL}$

(C) Till the block reaches its lowest position for the first time, the time duration for which the spring remains compressed is $\frac{\pi}{4}\sqrt{\frac{L}{g}} + \sqrt{\frac{L}{4g}}\ \sin^{-1}\frac{1}{3}$

(D) None of these

6. When free end of spring just touches the ground, the velocity of the block at that instant is 'v'. then which of the following is (are) true :

(A) The magnitude of velocity 'v' is $\sqrt{2gL}$.

(B) Block will regain the velocity of magnitude 'v', when compression in spring is $\frac{L}{2}$

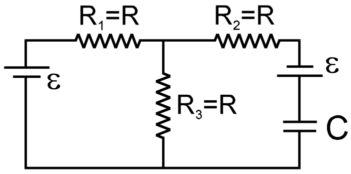
(C) Block will reach the velocity of magnitude 'v', twice in a cycle.

(D) Block will reach the velocity of magnitude 'v', four times in a cycle.

7. When spring just touches the ground, take that instant as t = 0 and velocity of block at that instant as v. Then the time 't' at which block will have the same magnitude of velocity 'v' is (are) given by :
Given :
(A) At time instant t_0, block first time reaches its mean position.
(B) T = time period of S.H.M.

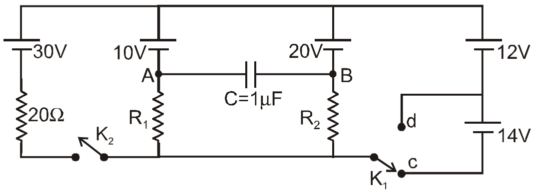
(A) $t = 2t_0$, (B) $t = \frac{T}{2}$ (C) $t = \frac{T}{2} + 2t_0$ (D) $t = \frac{T}{2} - t_0$

8. In the figure shown the capacitor is initially uncharged. Find the current in R_3 (= R) at time 't'.



9. The equation of a travelling wave in a uniform string of mass per unit length μ is given as y = A sin (ωt – kx). Find the total energy transferred through the origin in time interval from t = 0 to $t = \frac{\pi}{12\omega}$. [You can use the formula of instantaneous power if you know]

10. A circuit involving five ideal cells, three resistors (R_1, R_2 and 20Ω) and a capacitor of capacitance C = 1 μF is shown. Match the conditions in column-I with results given in column-II.



Column-I	Column-II
(A) K_2 is open and K_1 is in position C	(p) Potential at point A is greater than potential at B
(B) K_2 is open and K_1 is in position D	(q) Current through R_1 is downward
(C) K_2 is closed and K_1 is in position C	(r) Current through R_2 is upward
(D) K_2 is closed and K_1 is in position D	(s) Charge on capacitor is 10μC.

DPP No. : C11 (JEE-Advanced)

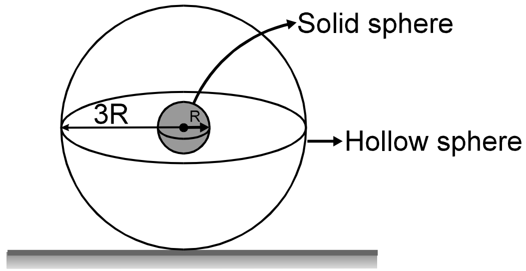
Total Marks : 38	Max. Time : 27 min.
Single choice Objective ('–1' negative marking) Q.1 to Q.3	(3 marks, 2 min.) [09, 06]
One or more than one options correct type ('–1' negative marking) Q.4 to Q.5	(4 marks 2 min.) [08, 04]
Comprehension ('–1' negative marking) Q.6 to Q.8	(3 marks 2 min.) [09, 06]
Subjective Questions ('–1' negative marking) Q.9	(4 marks 5 min.) [04, 05]
Match the Following (no negative marking) Q.10	(8 marks, 6 min.) [08, 06]

1. In an experiment the angles are required to be measured using an instrument. 29 divisions of the main scale exactly coincide with the 30 divisions of the vernier scale. If the smallest division of the main scale is half-a-degree (0.5°), then the least count of the instrument is:
(A) half minute (B) one degree (C) half degree (D) one minute

2. In an optics experiment, with the position of the object fixed, a student varies the position of the convex lens and for each position, the screen is adjusted to get a clear image of the object. A graph between the object distance u and the image distance v, from the lens, is plotted using the same scale for the two axes. A straight line passing through the origin and making an angle of 45° with the x-axis meets the experimental curve at P. The coordinates of P will be:

(A) $\left(\frac{f}{2}, \frac{f}{2}\right)$ (B) (f, f) (C) (4f, 4f) (D) (2f, 2f)

3. A solid ball of mass m and radius R is released from the position shown in a large hollow fixed shell of same mass m and radius 3R as shown in figure. The displacement of the centre of mass of the system from its initial position when the solid ball touches the lower surface of the hollow shell is : (centres of both the spheres coincide initially) :



(A) 0 (B) 3R (C) 2R (D) R

4. A small current element of length '$d\ell$' and carrying current is placed at (1, 1, 0) and is carrying current in '$+z$' direction. If magnetic field at origin be $\vec{B}_1$ and $\vec{B}_2$ at point (2, 2, 0) be then:

(A) $|\vec{B}_1| = |\vec{B}_2|$ (B) $\vec{B}_1 = -\vec{B}_2$ (C) $|\vec{B}_1| = |2\vec{B}_2|$ (D) $\vec{B}_1 = -2\vec{B}_2$

5. A 20 gm particle is subjected to two simple harmonic motions

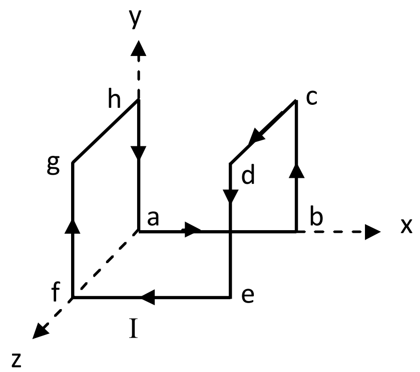
$x_1 = 2 \sin 10t$,

$x_2 = 4 \sin (10t + \frac{\pi}{3})$. where x_1 & x_2 are in metre & t is in sec.

(A) The displacement of the particle at t = 0 will be $2\sqrt{3}$ m.
(B) Maximum speed of the particle will be $20\sqrt{7}$ m/s.
(C) Magnitude of maximum acceleration of the particle will be 200 $\sqrt{7}$ m/s^2.
(D) Energy of the resultant motion will be 50 J.

COMPREHENSION

A current I amperes flows through a loop abcdefgha along the edge of a cube of width ℓ metres as shown in figure. One corner 'a' of the loop lies at origin.



6. This current path (abcdefgha) can be treated as a superposition of three square loops carrying current I. Choose the correct option?

(A) fghaf, fabef, ebcde (B) fghaf, fabef, fgdef
(C) fghaf, abcha, ebcde (D) fgdef, fabef, ebcde

7. The unit vector in the direction of magnetic field at the the centre of cube abcdefgh of width ℓ is given by

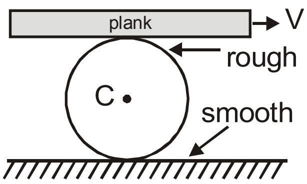
(A) $\hat{i}$ (B) $-\hat{j}$ (C) $\frac{2\hat{i}-\hat{j}}{\sqrt{5}}$ (D) $\hat{k}$

8. Now if a uniform external magnetic field is $\vec{B} = B_o\hat{j}$ is switched on, then the unit vector in the direction of torque due to external magnetic field ($\vec{B}$) acting on the current carrying loop (abcdefgha) is

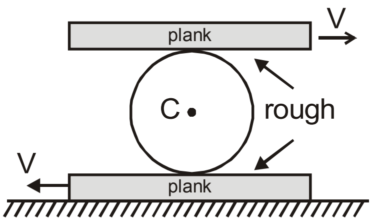
(A) $\hat{k}$ (B) $-\hat{i}$ (C) $\frac{2\hat{i}-\hat{j}}{\sqrt{5}}$ (D) none of these

9. Find the amplitude (in S.I. units) of resultant SHM of a particle in xy plane due to superposition of SHMs $x = 3 \sin \omega t$ and $y = 4 \sin \omega t$ where x, y and t are in S.I. units and ω is a constant.

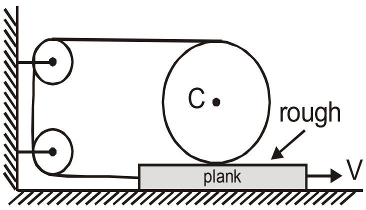
10. There are four arrangements of a cylinder and a plank as shown in the figures. Some surfaces are smooth and some are rough as indicated. There is no slipping at each rough surface. The plank and/or centre of cylinder are given a horizontal constant velocity as shown in each of the situations. Using this information fill in the blanks.

(i) 

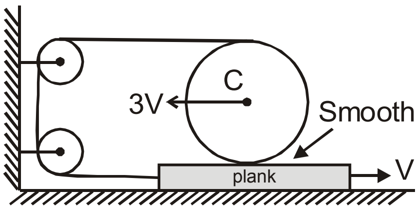
The speed of center of mass of the cylinder is ___________.

(ii) 

The angular velocity of the cylinder is __________.

(iii) 

The speed of center of mass of the cylinder is _________ .

(iv) 

The angular velocity of the cylinder is ___________ .

(a) V
(b) V/R
(c) 2V/R
(d) 4V/R
(e) cannot be determined from the given information
(f) Zero.

(A) (i) d (ii) b (iii) f (iv) c
(B) (i) e (ii) b (iii) f (iv) c
(C) (i) e (ii) d (iii) f (iv) c
(D) (i) e (ii) b (iii) f (iv) a

DPP No. : C12 (JEE-Main)

Total Marks : 61		**Max. Time : 40 min.**
Single choice Objective ('–1' negative marking) Q.1 to Q.19	**(3 marks, 2 min.)**	**[57, 38]**
One or more than one options correct type ('–1' negative marking) Q.20	**(4 marks 2 min.)**	**[04, 02]**

1. The focal lengths of the objective & the eyepiece of a compound microscope are 1 cm & 5 cm respectively. An object placed at a distance of 1.1 cm from the objective has its final image formed at 25 cm from the eye piece. The length of the microscope tube is:

(A) 6.1 cm (B) 49/8 cm (C) 6 cm (D) 91/6 cm

2. A Galileo telescope has an objective of focal length 100 cm & magnifying power 50. The distance between the two lenses in normal adjustment will be

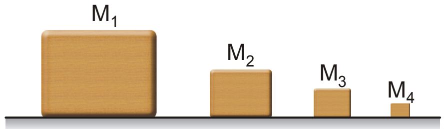
(A) 150 cm (B) 100 cm (C) 98 cm (D) 200 cm

3. A dipole of dipole moment p is kept at the centre of a ring of radius R and charge Q. The dipole moment has direction along the axis of the ring. The resultant force on the ring due to the dipole is:

(A) zero (B) $\frac{kPQ}{R^3}$ (C) $\frac{2kPQ}{R^3}$

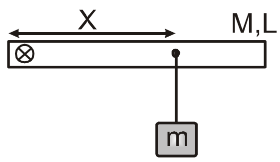
(D) $\frac{kPQ}{R^3}$ only if the charge is uniformly distributed on the ring

4. Four blocks of masses M_1, M_2, M_3 and M_4 are placed on a smooth horizontal surface along a straight line as shown. It is given that $M_1 >> M_2 >> M_3 >> M_4$. All the blocks are initially at rest. M_1 is given initial velocity v_0 towards right such that it will collide with M_2. Consider all collisions to be perfectly elastic. The speed of M_4 after all collision are over is



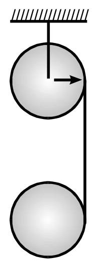
(A) v_0 (B) $4v_0$ (C) $8v_0$ (D) $16v_0$

5. A small block is hanged by a string of small length at a distance ' x ' from left end on a uniform rod of length L and mass M. The rod is in horizontal position and hinged at left end as shown in figure. Then minimum value of ' x ' ($x \neq 0$) for which initial acceleration will be independent of ' m ' mass of the block.



(A) L (B) $\frac{2L}{3}$ (C) $\frac{L}{3}$ (D) can't be determined

6. Two identical discs of mass m and radius r are arranged as shown in the figure. If α is the angular acceleration of the lower disc and a_{cm} is acceleration of centre of mass of the lower disc, then relation between a_{cm}, α & r is :



(A) $a_{cm} = \frac{\alpha}{r}$ (B) $a_{cm} = 2\alpha r$

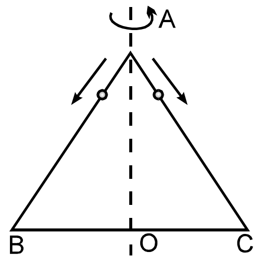
(C) $a_{cm} = \alpha r$ (D) none of these

7. Moment of inertia of a uniform quarter disc of radius R and mass M about an axis through its centre of mass and perpendicular to its plane is :

(A) $\frac{MR^2}{2} - M\left(\frac{4}{3}\frac{R}{\pi}\right)^2$ (B) $\frac{MR^2}{2} - M\left(\sqrt{2}\frac{4}{3}\frac{R}{\pi}\right)^2$

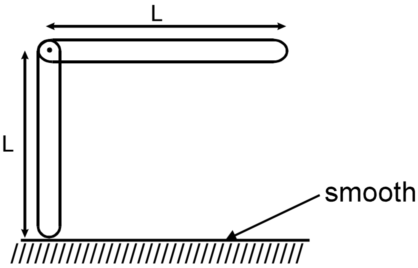
(C) $\frac{MR^2}{2} + M\left(\frac{4}{3}\frac{R}{\pi}\right)^2$ (D) $\frac{MR^2}{2} + M\left(\sqrt{2}\frac{4}{3}\frac{R}{\pi}\right)^2$

8. An equilateral triangle ABC formed from a uniform wire has two small identical beads initially located at A. The triangle is set rotating about the vertical axis AO. Then the beads are released from rest simultaneously and allowed to slide down, one along AB and the other along AC as shown. Neglecting frictional effects, the quantities that are conserved as the beads slide down, are:



(A) angular velocity and total energy (kinetic energy and potential energy)
(B) total angular momentum and total energy
(C) angular velocity and moment of inertia about the axis of rotation
(D) total angular momentum and moment of inertia about. the axis of rotaiton

9. Two identical rods are joined at one of their ends by a pin. Joint is smooth and rods are free to rotate about the joint. Rods are released in vertical plane on a smooth surface as shown in the figure. The displacement of the joint from its initial position to the final position is (i.e. when the rods lie straight on the ground) :



(A) $\frac{L}{4}$ (B) $\frac{\sqrt{17}}{4}$ L (C) $\frac{\sqrt{5}\,L}{2}$ (D) none of these

10. At t = 0, a particle of mass m starts moving from rest due to a force $\vec{F} = F_0 \sin(\omega t)\hat{i}$.
(A) Particle performs SHM about its initial position of rest.
(B) Particle performs SHM with initial position as an extreme position with angular frequency ω.
(C) At any instant, distance moved by the particle equals its displacement from the initial position.
(D) Initially velocity of particle increases with time but after time t = $2\pi/\omega$ it becomes constant.

11. A small mass executes linear SHM about O with amplitude a and time period T. Its displacement from O at time T/8 after passing through O is:

(A) $\frac{a}{8}$ (B) $\frac{a}{2\sqrt{2}}$ (C) $\frac{a}{2}$ (D) $\frac{a}{\sqrt{2}}$

12. In forced oscillation of a particle, the amplitude is maximum for a frequency ω_1 of the force, while the energy is maximum for a frequency ω_2 of the force, then :
(A) $\omega_1 = \omega_2$
(B) $\omega_1 > \omega_2$
(C) $\omega_1 < \omega_2$ when damping is small and $\omega_1 > \omega_2$ when damping is large
(D) $\omega_1 < \omega_2$

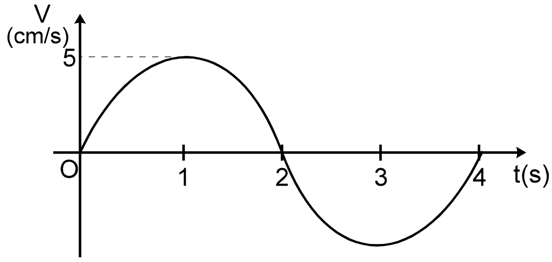
13. Equation F = –bv – kx represents equation of a damped oscillations for a particle of 2kg mass where $b = \ell n2 \frac{N.S.}{m}$ and k = 100 N/m then time after which energy of oscillations will be reduced to half of initial is:

(A) ℓn2 sec (B) 2 sec. (C) 2ℓn2 sec (D) 1 sec

14. At t = 0, a transverse wave pulse travelling in the positive x direction with a speed of 2 m/s in a long wire is described by the function $y = \frac{6}{x^2}$, given that $x \neq 0$. Transverse velocity of a particle at x = 2m and t = 2 seconds is :

(A) 3 m/s (B) – 3 m/s (C) 8 m/s (D) – 8 m/s

15. A certain transverse sinusoidal wave of wavelength 20 cm is moving in the positive x direction. The transverse velocity of the particle at x = 0 as a function of time is shown. The amplitude of the motion is:



(A) $\frac{5}{\pi}$ cm (B) $\frac{\pi}{2}$ cm (C) $\frac{10}{\pi}$ cm (D) 2π cm

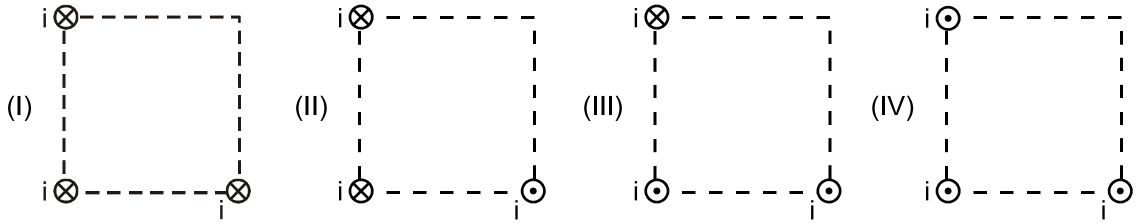
16. A man generates a symmetrical pulse in a string by moving his hand up and down. At t = 0 the point in his hand moves downward. The pulse travels with speed each 3 m/s on the string & his hands passes 6 times in each second from the mean position. Then the point on the string at a distance 3m will reach its upper extreme first time at time t =

(A) 1.25 sec. (B) 1 sec (C) $\frac{13}{12}$ sec. (D) none of these

17. A source of sound of frequency 165 Hz generates sound waves which get fully reflected from a wall. A person standing at the wall starts moving away from the wall. The minimum distance of the point from the wall at which the person hears maximum sound is: (velocity of sound = 330 ms^{-1})

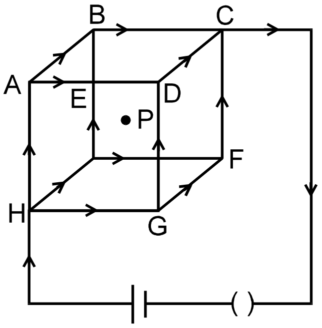
(A) 1 m (B) 2 m (C) 1/2 m (D) 1/4 m

18. Three long wires, with identical currents, either directly into or directly out of the page, are placed at three corners of a square in four different arrangements as shown. Correct order of the magnitude of net magnetic field at the empty upper right corner of the square is :



(A) $B_I = B_{IV} > B_{II} = B_{III}$ (B) $B_I > B_{IV} > B_{II} = B_{III}$
(C) $B_{II} = B_{III} > B_I = B_{IV}$ (D) $B_I > B_{III} > B_{II} > B_{IV}$

19. A steady current is set up in a cubic network composed of wires of equal resistance and length d as shown in figure. What is the magnetic field at the centre P due to the cubic network ?



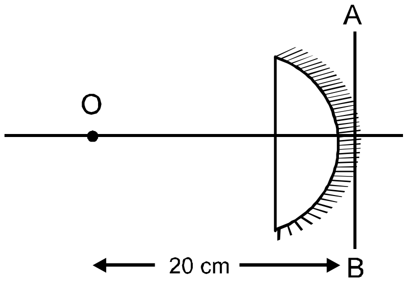
(A) $\frac{\mu_0}{4\pi}\frac{2I}{d}$ (B) $\frac{\mu_0}{4\pi}\frac{3I}{\sqrt{2}\,d}$ (C) 0 (D) $\frac{\mu_0}{4\pi}\frac{\theta\pi I}{d}$

20. The x-coordinate of a particle moving on x-axis is given by x = 3 sin 100t + 8 $\cos^2$ 50t, where x is in cm and t is time in seconds. Which of the following is/are correct about this motion.
(A) the motion of the particle is not S.H.M.
(B) the amplitude of the S.H.M. of the particle is 5 cm
(C) the amplitude of the resultant S.H. M. is $\sqrt{73}$ cm
(D) the maximum displacement of the particle from the origin is 9 cm.

DPP No. : C13 (JEE-Main)

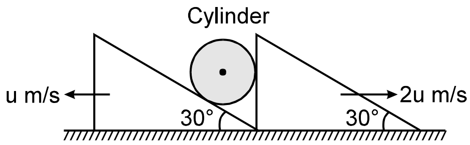
Total Marks : 60		**Max. Time : 40 min.**
Single choice Objective ('–1' negative marking) Q.1 to Q.20	**(3 marks, 2 min.)**	**[60, 40]**

1. A point object is placed at a distance of 20 cm from a thin plane convex lens of focal length 15 cm (n = 1.5). Now the curved surface is silvered. The image will be formed at :



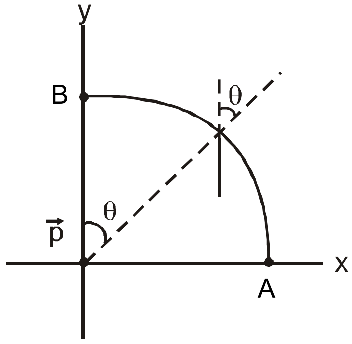
(A) 60 cm left of AB (B) 30 cm left of AB (C) $\frac{20}{7}$ cm left of AB (D) 60 cm right of AB

2. In the system shown in figure assume that cylinder remains in contact with the two wedges. The velocity of cylinder is -



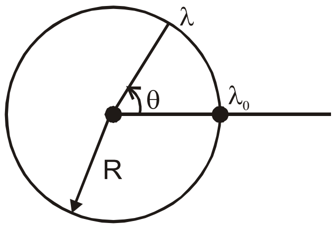
(A) $\sqrt{19-4\sqrt{3}}\,\frac{u}{2}$ m/s (B) $\frac{\sqrt{13}\,u}{2}$ m/s (C) $\sqrt{3}$ u m/s (D) $\sqrt{7}$ u m/s

3. A dipole is kept at origin along y-axis. As one moves from A to B along the curve, the direction of the electric field changes from negative y–direction to positive y–direction. The angle θ (with the dipole moment) at which y–component of electric field is zero is :



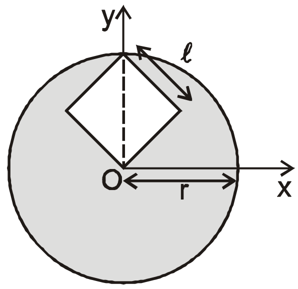
(A) 45º
(B) $\frac{1}{2}\tan^{-1}\frac{1}{2}$
(C) $\tan^{-1}\sqrt{2}$
(D) $\tan^{-1}$(B)

4. A thin non-conducting ring of radius R has a linear charge density $\lambda = \lambda_0 \cos\theta$, where θ is measured as shown. The total electric dipole moment of the charge distribution is :



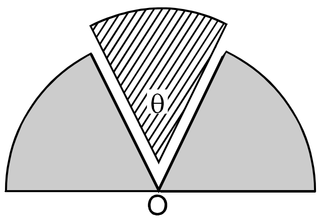
(A) $R^2\lambda_0$
(B) $2\pi R^2\lambda_0$
(C) $\frac{\pi R^2\lambda_0}{2}$
(D) $\pi R^2\lambda_0$

5. A disc (of radius r cm) of uniform thickness and uniform density ρ has a square hole with sides of length $\ell = \frac{r}{\sqrt{2}}$ cm. One corner of the hole is located at the center of the disc and centre of the hole lies on y-axis as shown. Then the y-coordinate of position of center of mass of disc with hole (in cm) is



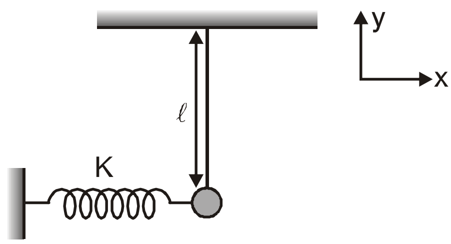
(A) $-\frac{r}{2(\pi - ¼)}$
(B) $-\frac{r}{4(\pi - ¼)}$
(C) $-\frac{r}{4(\pi - ½)}$
(D) $-\frac{3r}{4(\pi - ¼)}$

6. A segment of angle θ is cut from a half disc symmetrically as shown. If the centre of mass of the remaining part is at a distance 'a' from O and the centre of mass of the original disc was at distance d then it can be definitely said that :



(A) a = d
(B) a > d
(C) a < d
(D) A,B,C depends on the angle of segment cut from disc.

7. A small metal bob is suspended from a rigid support by means of an insulating string. The bob is connected to a non-conducting and initially undeformed spring, and in a region of uniform electric field $\vec{E} = E_0\hat{i}$. Then for a small charge +q on the bob, the elongation in the spring in equilibrium is (Assume spring remains horizontal)



(A) $\frac{qE}{\frac{mg}{\ell} + k}$
(B) $\frac{qE}{\frac{mg}{\ell} - k}$
(C) $\frac{qE}{mg}\ \ell$
(D) $\frac{qE}{k}$

8. Consider the interference pattern on a screen in youngs double slit experiment. In the vicinity of the geometrical centre O of the system on the screen
(A) the intensity of light is directly proportional to the distance from O
(B) the distance between two points where the intensity is same is equal to fringe width.
(C) the distance between two points where the intensity is same is equal to half of fringe width.
(D) the fringe pattern will not shift if the plane of the slits is rotated by small angle in its own plane keeping the mid point of the line joining the slits fixed.

9. Let S_1 and S_2 be the two slits in Young's double slit experiment. If central maxima is observed at P and angle $\angle S_1PS_2 = \theta$, then the fringe width for the light of wavelength λ will be. (Assume θ to be a small angle)
(A) λ/θ (B) $\lambda\theta$ (C) $2\lambda/\theta$ (D) $\lambda/2\theta$

10. In a YDSE both slits produce equal intensities on the screen. A 100 % transparent thin film is placed in front of one of the slits. Now the intensity of the geometrical centre of system on the screen becomes 75 % of the previous intensity. The wavelength of the light is 6000Å and $\mu_{film} = 1.5$. The thickness of the film **cannot be**:
(A) 0.2 μm (B) 1.0 μm (C) 1.4 μm (D) 1.6 μm

COMPREHENSION :

ELECTROMAGNETIC WAVES

Sources of electromagnetic waves

It is an important result of Maxwell's theory that accelerated charges radiate electromagnetic waves. The proof of this basic result is beyond the scope of this book, but we can accept it on the basis of rough qualitative reasoning. Consider a charge oscillating with some frequency. (An oscillating charge is an example of accelerating charge.) This produces an oscillating electric field in space, which produces an oscillating magnetic field, which in turn, is a source of oscillating electric field, and so on. The oscillating electric and magnetic fields thus regenerate each other as the waves propagates through the space. The frequency of electromagnetic wave naturally equals the frequency of oscillation of the charge. The energy associated with the propagating wave comes at the expense of the energy of the source-the accelerated charge.
It can be shown from Maxwell's equations that electric and magnetic field in an electromagnetic wave are perpendicular to each other and to the direction of propagation.
In Fig 4, we show a typical example of a plane electromagnetic wave propagating along the z direction (the fields are shown as a function of the z coordinate, at a given time t). The electric field E_x is along the x-axis, and varies sinusoidally with z, at a given time. The magnetic field B_y is along the y-axis and again varies sinusoidally with z. The electric and magnetic fields E_x and B_y are perpendicular to each other, and to the direction z of propagation. We can write E_x and B_y as follows :

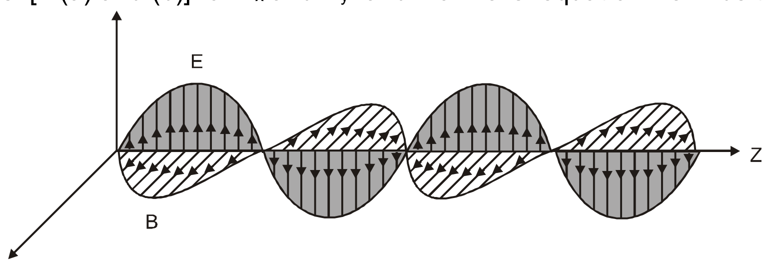
$E_x = E_0 \sin (kz - \omega t)$ .... Eq. 7(a)

$B_y = B_0 \sin (kz - \omega t)$ .... Eq. 7 (b)

Here k is related to the wave length λ of the wave by the usual equation

$k = \dfrac{2\pi}{\lambda}$ .... Eq. 8

and ω is the angular frequency. k is the magnitude of the wave vector (or propagation vector) k and its irection describes the direction of propagation of the wave. The speed of propagation of the wave is (ω/k). Using Eqs. [7 (a) and (b)] for E_x and B_y and Maxwells equation we finds that



$\omega = cK$, where, $c = 1/\sqrt{\mu_0\varepsilon_0}$ ....Eq.9 (a)

The relation $\omega = cK$ is the standard one for waves. This relation is often written in terms of frequency. ν $(=\omega/2\pi)$ and wavelength. λ $(= 2\pi / k)$ as

$2\pi\nu = c\left(\frac{2\pi}{\lambda}\right)$ or

$\nu\lambda = c$ ....Eq. 9(b)

It is also seen from Maxwell's equations that the magnitude of the electric and the magnetic fields in an electromagnetic waves are related as $B_0 = E_0 / c$.

The properties of electromagnetic waves can be summarized as follows :

1. These waves do not required any material medium to propagate.

2. These are produced by accelerating charges

3. These waves consist of time varying electric field and magnetic field.

$E_x = E_0 \sin(kz - \omega t)$

$B_y = B_0 \sin(kz - \omega t)$

4. The frequency of an electromagnetic wave is equal to the frequency of oscillations of electric field and magnetic field. The frequency $f = \frac{\omega}{2\pi}$

5. Electric field and magnetic field associated with an EM wave are always perpendicular to each other.

6. Electric field and magnetic field associated with an EM wave are also in same phase. The ratio of $|\vec{E}|$ and $|\vec{B}|$ is equal to c.

7. The direction of propogation of EM wave is perpendicular to electric field and magnetic field. The direction of propagation is in the direction of $\vec{E}\times\vec{B}$.

8. In vaccum EM waves propogates with speed equal to 3×10^8 m/s, it is represented by the symbol c. c is also equal to $1/\sqrt{\mu_0\varepsilon_0}$.

9. In other medium EM wave propagate with a speed = $\frac{1}{\sqrt{\mu\varepsilon}}$.

On the basis of above information answer following questions :

11. A plane electromagnetic wave of frequency 25 MHz travels in free space along the x-direction. At a particular point in space and time, **E** = $6.3\,\hat{j}$ V/m. What is B at this point ?

12. The magnetic field in a plane electromagnetic wave is given by
$B_y = 2 \times 10^{-7} \sin(0.5 \times 10^3 x + 1.5 \times 10^{11} t)$ T.
(a) What is the wavelength and frequency of the wave ?
(b) Write an expression for the electric field.

13. An electromagnetic wave travelling in the x-direction has frequency of 2×10^{14} Hz and electric field amplitude of 27 Vm^{-1}. From the options given below, which one describes the magnetic field for this wave ?

(A) $\vec{B}(x,\ t) = (9\times10^{-8}T)\hat{j}$ $\sin\left[1.5\times10^{-6}x - 2\times10^{14}t\right]$

(B) $\vec{B}(x,\ t) = (9\times10^{-8}T)\hat{i}$ $\sin\left[2\pi(1.5\times10^{-8}x - 2\times10^{14}t)\right]$

(C) $\vec{B}(x,\ t) = (9\times10^{-8}T)\hat{k}$ $\sin\left[2\pi(1.5\times10^{-6}x - 2\times10^{14}t)\right]$

(D) $\vec{B}(x,\ t) = (3\times10^{-8}T)\hat{j}$ $\sin\left[2\pi(1.5\times10^{-8}x - 2\times10^{14}t)\right]$

14. For plane electromagnetic waves propagating in the z direction, which one of the following combination gives the correct possible direction for $\vec{E}$ and $\vec{B}$ field respectively ?

(A) $\left(2\hat{i}+3\hat{j}\right)$ and $\left(\hat{i}+2\hat{j}\right)$ (B) $(-2\hat{i}-3\hat{j})$ and $(3\hat{i}-2\hat{j})$

(C) $\left(3\hat{i}+4\hat{j}\right)$and $\left(4\hat{i}-3\hat{j}\right)$ (D) $\left(\hat{i}+2\hat{j}\right)$ and $\left(2\hat{i}-\hat{j}\right)$

15. If an electromagnetic wave propagating through vacuum is described by
$E = E_0 \sin(kx - \omega t)$; $B = B_0 \sin(kx - \omega t)$,

(A) $E_0 k = B_0 \omega$ (B) $E_0B_0 = \omega k$ (C) $E_0 \omega = B_0 k$ (D) $E_0 B_0 = \omega / k$

16. The electric field part of an electromagnetic wave in a medium is represented by
$E_x = 0$;

$$E_y = 2.5\frac{N}{C}\cos\left[\left(2\pi\times10^6\frac{rad}{s}\right)t-\left(\pi\times10^{-2}\frac{rad}{m}\right)x\right]$$

$E_z = 0$. The wave is :

(A) moving along y direction with frequency $2\pi \times 10^6$ Hz and wavelength 200 m.
(B) moving along x direction with frequency 10^6 Hz and wavelength 100m
(C) moving along x direction with frequency 10^6 Hz and wavelength 200m
(D) moving along –x direction with frequency 10^6 Hz and wavelength 200m

17. The electric field of an electromagnetic wave in free space is given by $\vec{E} = 10\cos(10^7 t + kx)\hat{j}$ V/m, where t and x are in seconds and metres respectively. It can be inferred that

(i) the wavelength λ is 188.4 m. (ii) the wave number k is 0.33 rad/m
(iii) the wave amplitude is 10 V/m (iv) the wave is propagating along +x direction

Which one of the following pairs of statements is correct ?

(A) (iii) and (iv) (B) (i) and (ii)
(C) (ii) and (iii) (D) (i) and (iii)

18. A light beam travelling in the x-direction is described by the eletric field E_y = (300 V/m) $\sin\omega(t - x/c)$. An electron is constrained to move along the y-direction with a speed of 2.0×10^7 m/s. The maximum electric force and the maximum magnetic force on the electron are-

(A) 4.8×10^{-17} N,zero (B) 4.2×10^{-18} N, 1.8×10^{-8}
(C) 4.8×10^{-17} N,3.2×10^{-18} N (D) zero, zero

19. The magnetic field in a travelling electromagnetic wave has a peak value of 20 nT. The peak value of electric field strength is : **[JEE (Main) 2013, 4/120, –1]**

(A) 3V/m (B) 6V/m (C) 9V/m (D) 12 V/m

20. An EM wave from air enters a medium. The electric fields are $\vec{E}_1 = E_{01}\hat{x}\cos\left[2\pi\nu\left(\frac{z}{c}-t\right)\right]$ in air and $\vec{E}_2 = E_{02}\hat{x}\cos\left[k(2z-ct)\right]$ in medium, where the wave number k and frequency υ refer to their values in air. The medium is non-magnetic. If ε_{r_1} and ε_{r_2} refer to relative permittivities of air and medium respectively, which of the following options is correct ? **[JEE (Main) 2018; 4/120, –1]**

(A) $\frac{\varepsilon_{r_1}}{\varepsilon_{r_2}} = \frac{1}{4}$ (B) $\frac{\varepsilon_{r_1}}{\varepsilon_{r_2}} = \frac{1}{2}$ (C) $\frac{\varepsilon_{r_1}}{\varepsilon_{r_2}} = 4$ (D) $\frac{\varepsilon_{r_1}}{\varepsilon_{r_2}} = 2$

DPP No. : C14 (JEE-Advanced)

Total Marks : 33		**Max. Time : 22 min.**
Comprehension ('–1' negative marking) Q.1 to Q.11	**(3 marks 2 min.)**	**[33, 22]**

COMPREHENSION :

Electromagnetic waves carry energy and momentum. In a region of free space with electric field E, there is an energy density ($\varepsilon_0 E^2/2$). Similarly, as seen associated with a magnetic field B is a magnetic energy density ($B^2 / 2\mu_0$). As electromagnetic wave contains both electric and magnetic fields, there is a non-zero energy density associated with it. Since it carries momentum, an electromagnetic wave also exerts pressure called radiation pressure. If the total energy transferred to a surface in time t is U. It can be shown that the magnitude of the total momentum delivered to this surface (for complete absorption) is,

$$p = \frac{U}{c}$$

Light carries energy from the sun to the earth, thus making life possible on the earth.

1. Light with an energy flux of 18 W/cm^2 falls on a nonreflecting surface at normal incidence. If the surface has an area of 20cm^2, find the average force exerted on the surface during a 30 minute time span.

2. Calculate the electric and magnetic fields produced by the radiation coming from a 100 W bulb at a distance of 3 m. Assume that the efficiency of the bulb is 2.5% and it is a point source.

3. Find the energy stored in a 60 cm length of a laser beam operating at 4 mW.
(A) 8×10^{-12}J (B) 6×10^{-12}J (C) 4×10^{-12}J (D) 7×10^{-12}J

4. During the propagation of electromagnetic waves in a medium : **[JEE (Main) 2014, 4/120, –1]**
(A) Electric energy density is double of the magnetic energy density.
(B) Electric energy density is half of the magnetic energy density.
(C) Electric energy density is equal to the magnetic energy density.
(D) Both electric and magnetic energy densities are zero.

5. An electromagnetic wave of frequency 1×10^{14} hertz is propagating along z–axis. The amplitude of electric field is 4V/m. If $\epsilon_0 = 8.8 \times 10^{-12}$ C^2/N–m^2, then average energy density of electric field will be :
[JEE (MAIN) 2014_ONLINE TEST]
(A) 35.2×10^{-11} J/m^3 (B) 35.2×10^{-12} J/m^3 (C) 35.2×10^{-13} J/m^3 (D) 35.2×10^{-10} J/m^3

6. An electromagnetic wave of frequency n = 3.0 MHz passes vacuum into a dielectric medium with permittivity $\varepsilon = 4.0$, then **[AIEEE 2004; 3/225, –1]**
(A) wavelength is doubled and the frequency remains unchanged
(B) wavelength is doubled and frequency becomes half
(C) wavelength is halved and frequency remains unchanged
(D) wavelength and frequency both remain unchanged

7.✍ An electromagnetic wave in vacuum has the electric and magnetic field $\vec{E}$ and $\vec{B}$, which are always perpendicular to each other. The direction of polarization is given by $\vec{X}$ and that of wave propagation by $\vec{k}$. Then **[AIEEE 2012, 4/120, – 1]**
(A) $\vec{X} \| \vec{B}$ and $\vec{k} \| \vec{B} \times \vec{E}$ (B) $\vec{X} \| \vec{E}$ and $\vec{k} \| \vec{E} \times \vec{B}$
(C) $\vec{X} \| \vec{B}$ and $\vec{k} \| \vec{E} \times \vec{B}$ (D) $\vec{X} \| \vec{E}$ and $\vec{k} \| \vec{B} \times \vec{E}$

COMPREHENSION :

DISPLACEMENT CURRENT

We have seen that an electrical current produces a magnetic field around it. Maxwell showed that for logical consistency, a changing electric field must also produce a magnetic field. This effect is of great importance because it explains the existence of radio waves, gamma rays and visible light, as well as all other forms of electromagnetic waves.

To see how a changing electric field gives rise to a magnetic field, let us consider the process of charging of a capacitor and apply Ampere's circuital law given by

$$\oint B.\ dl = \mu_0 i(t) \qquad \text{........ (A)}$$

to find magnetic field at a point outside the capacitor. Figure 1 (a) shows a parallel plate capacitor C which is a part of circuit through which a time-dependent current i (t) flows. Let us find the magnetic field at a point such as P, in a region outside the parallel plate capacitor. For this, we consider a plane circular loop of radius r whose plane is perpendicular to the direction of the current - Carrying wire, and which is centred symmetrically with respect to the wire. From symmetry, the magnetic field is directed along the circumference of the circular loop and is the same in magnitude at all points on the loop so that if B is the magnitude of the field, the left side of equation. (8.1) is B $(2\pi r)$. So we have

$$B\,(2\pi r) = \mu_0\, i\,(t) \qquad \text{......... (B)}$$

Now, consider a different surface, which has the same boundary. This is a pot like surface (Fig.1 (b)] which nowhere touches the current, but has its bottom between the capacitor plates; its mouth is the circular loop mentioned above. Another such surface is shaped like a tiffin box (without the lid) [Fig. 1 (c)]. On applying Ampere's circuital law to such surfaces with the same perimeter, we find that the left hand side of Eq. (A) has not changed but the right hand side is zero and not μ_0 i, since no current passes through the surface of Fig 1 (b) and (c). So we have a contradiction; calculated one way, there is a magnetic field at a point P; calculated another way, the magnetic field at P is zero. Since the contradiction arises from our use of Ampere's circuital law, this law must be missing something. The missing term must be such that one gets the same magnetic field at point P, no matter what surface is used.

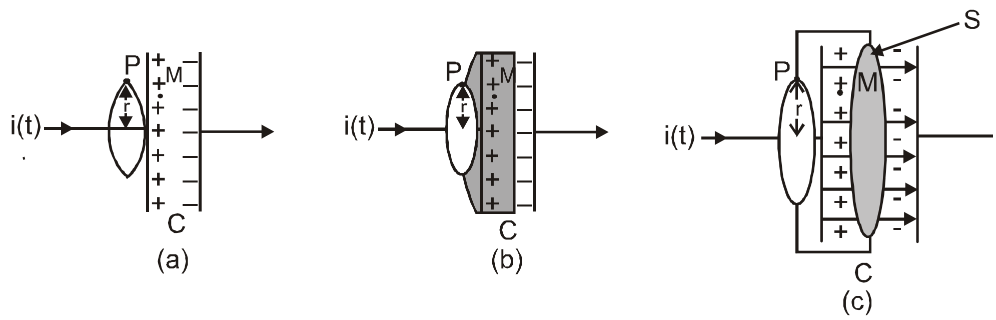


Figure 1

We can actually guess the missing term by looking carefully at Fig. 1 (c). Is there anything passing through the surface S between the plates of the capacitor ? Yes, of course, the electric field. If the plates of the capacitor have an area A, and a total charge Q, the magnitude of the electric field **E** between the plates is$(Q/A)/\varepsilon_0$. The field is perpendicular to the surface S of Fig.1 (c). It has the same magnitude over the area A of the capacitor plates, and vanishes outside it. So what is the electric flux Φ_E through the surface S ? Using Gauss's law, it is

$$\Phi_E = |E|\ A = \frac{1}{\varepsilon_0}\frac{Q}{A}\ A = \frac{Q}{\varepsilon_0} \qquad \text{............ (C)}$$

Now if the charge Q on the capacitor plates changes with time, there is a current i = (dQ / dt), so that using Eq. (C), we have

$$\frac{d\Phi_E}{dt} = \frac{d}{dt}\left(\frac{Q}{\varepsilon_0}\right) = \frac{1}{\varepsilon_0}\frac{dQ}{dt}$$

This implies that for consistency,

$$\varepsilon_0 \left(\frac{d\Phi_E}{dt}\right) = i \qquad \text{............ (D)}$$

This is the missing term in Ampere's circuital law. If we generalis this law by adding to the total current carried by conductors through the surface, another term which is ε_0 times the rate of change of electric flux through the same surface, the total has the same value of current i for all surfaces. If this is done, there is no contradiction in the value of B obtained anywhere using the generalized Amper's law. B at the point P is non-zero no matter which surface is used for calculating it. B at a point P outside the plates [Fig.1 (a)] is the same as at a point M just inside, as it should be. The current carried by conductors due to flow of charges is called conduction current. The current, given by Eq. (D), is a new term, and is due to changing electric field (or electric displacement). It is therefore called displacement current or Maxwell's displacement current. Figure 2 shows the electric and magnetic fields inside the parallel plates capacitor discussed above. The generalisation made by Maxwell then is the following.

The source of a magnetic field is not just the conduction electric current due to flowing charges, but also the time rate of change of electric field. More precisely, the total current i is the sum of the conduction current denoted by i_C, and the displacement current denoted by i_d ($=\varepsilon_0(d\Phi_E)/dt$). So we have

$$i = i_e + i_d = i_c + \varepsilon_0 \frac{d\Phi_E}{dt} \qquad \text{............ (5)}$$

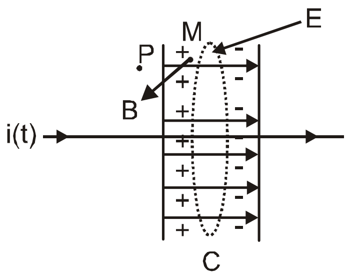


Figure 2 (a)

In explicit terms, this means that outside the capacitor plates, we have only conduction current $i_c = i$, and no displacement current, i.e., $i_d = 0$. On the other hand, inside the capacitor, there is no conduction current, i.e., $i_c = 0$, and there is only displacement current, so that $i_d = i$.

The generalised (and correct) Ampere's circuital law has the same form as Eq, (A), with one difference: " the total current passing through any surface of which the closed loop is the perimeter" is the sum of the conduction current and the displacement current The generalised law is

$$\oint B \bullet d\ell = \mu_0 i_c + \mu_0 \varepsilon_0 \frac{d\Phi_E}{dt} \qquad \text{...........}$$

(6)

and is known as Ampere-Maxwell law.

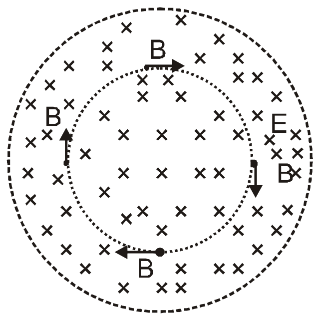


Figure 2(b)

In all respects, the displacement current has the same physical effects as the conduction current. In some cases, for example, steady electric fields in a conducting wire, the displacement current may be zero since the electric field E does not change with time.

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Maxwell's Equations

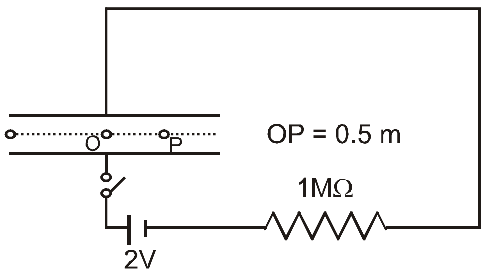
1. $\oint E \bullet dA = Q/\varepsilon_0$ (Gauss's Law for electricity)

2. $\oint B \bullet dA = 0$ (Gauss's Law for magnetism)

3 $\oint E \bullet d\ell = \frac{-d\Phi_B}{dt}$ (Faraday's Law)

4. $\oint B \bullet d\ell = \mu_0 i_c + \mu_0 \varepsilon_0 \frac{d\Phi_E}{dt}$ (Ampere - Maxwell Law)

8. A parallel plate capacitor with circular plates of radius 1 m has a capacitance of 1 nF. At t = 0, it is connected for charging in series with a resistor R = 1 M Ω across a 2 V battery (as shown). Calculate the magnetic field at a point P. halfway between the centre and the periphery of the plates, after $t = 10^{-3}$ s. (The charge on the capacitor at time t is q (t) = CV [1 – exp (–t / τ)], where the time constant τ is equal to CR)



9. A parallel-plate capacitor with plate area A and separation between the plates d, is charged by a constant current i. Consider a plane surface of area A/2 parallel to the plates and drawn symmetrically between the plates. Find the displacement current through this area.

(A) i (B) $\frac{i}{2}$ (C) 2i (D) zero

10. A parallel-plate capacitor having plate area A and plate separation d is joined to a battery of emf e and internal resistance R at t = 0 consider a plane surface of area A/2 parallel to the plates and situated symmetrically between them. Find the displacement current through this surface as a function of time.

(A) $\frac{\varepsilon}{2R} e^{\frac{-td}{\varepsilon AR}}$ (B) $\frac{\varepsilon}{R} e^{\frac{-td}{\varepsilon AR}}$ (C) $\frac{2\varepsilon}{R} e^{\frac{-td}{\varepsilon AR}}$ (D) $\frac{\varepsilon}{2R} e^{\frac{-2td}{\varepsilon AR}}$

11. If E denotes the intensity of electric field, the dimensions of a quantity $\epsilon_0 \frac{dE}{dt}$ are those of

(A) current (B) current density (C) electric potential (D) electric flux

DPP No. : C15

Total Marks : 66	**Max. Time : 44 min.**
Single choice Objective ('–1' negative marking) Q.1 to Q.22	**(3 marks 2 min.) [66, 44]**

1. A digital signal –
(A) is less reliable than analog signal (B) is more reliable than analog signal
(C) is equally reliable as the analog signal (D) none of the above

2. Modern communication systems use :
(A) analog circuits (B) digital circuits
(B) combination of analog and digital circuits (D) none of the above

3. The audio signal -
(A) can be sent directly over the air for large distance
(B) cannot be sent directly over the air for large distance
(C) possess very high frequency
(D) none of the above

4. The process of changing some characteristic of a carrier wave in accordance with the intensity of the signal is called -
(A) amplification (B) rectification (C) modulation (D) none of these

5. If a carrier wave of 1000 kHz is used to carry the signal, the length of transmitting antenna will be equal to -
(A) 3 m (B) 30 m (C) 300 m (D) 3000 m

6. The types of modulation which are possible, are -
(A) one only (B) two only (C) three only (D) none of these

7. In amplitude modulation -
(A) only the amplitude is changed but frequency remains same
(B) both the amplitude and frequency change equally
(C) both the amplitude and frequency change unequally
(D) none the these

8. Modulation factor determines -
(A) only the strength of the transmitted signal (B) only the quality of the transmitted signal
(C) both the strength and quality of the signal (D) none of the above

9. Degree of modulation –
(A) can take any value (B) should be less than 100%
(C) should exceed 100% (D) none of these

10. If the maximum and minimum voltage of an AM wave are $V_{max.}$ and $V_{min.}$ respectively then modulation factor–
(A) $m = \frac{V_{max.}}{V_{max.} + V_{min.}}$ (B) $m = \frac{V_{min.}}{V_{max.} + V_{min.}}$ (C) $m = \frac{V_{max.} + V_{min.}}{V_{max.} - V_{min.}}$ (D) $m = \frac{V_{max.} - V_{min.}}{V_{max.} + V_{min.}}$

11. The AM wave contains three frequencies, viz :
(A) $\frac{f_c}{2}, \frac{f_c + f_s}{2}, \frac{f_c - f_s}{2}$ (B) $2f_c$, $2(f_c + f_s)$, $2(f_c - f_s)$
(C) f_c,$(f_c + f_s)$, $(f_c - f_s)$ (D) f_c , f_c, f_c

12. For a carrier frequency of 100 kHz and a modulating frequency of 5 kHz what is the width of AM transmission–
(A) 5 kHz (B) 10kHz (C) 20 kHz (D) 200 KHz

13. Intelsat satellite is used for :
(A) radio communication (B) intercontinental communication
(C) radar communication (D) none of the above

14. A geo-synchronous satellite is :
(A) located at a height of 35,860 km to ensure global coverage
(B)appears stationary over the earth's magnetic pole
(C) not really stationary at all, but orbits the earth within 24 hrs
(D) motionless in space (except for its spin)

15. The frequency band used for radar relay systems and television -
(A) UHF (B) VLF (C) VHF (D) EHF

16. In which of the region of earth's atmosphere temperature decreases with height?
(A) Ionosphere (B) Stratosphere (C) Troposphere (D) Mesosphere

17. Major parts of a communications systems are :
(A) transmitter and receiver (B) receiver and communication channel
(C) transmitter and communication channel (D) transmitter, receiver and communication channel

18. In an amplitude modulated wave, for audio frequency of 500 cps, the appropriate carrier frequency will be :
(A) 50 c/s (B) 100 c/s (C) 500 c/s (D) 50000 c/s

19. In A.M., the total modulation index should not exceed one or else :
(A) the system will fail (B) distortion will result
(C) amplifier will be damaged (D) none of the above

20. An 'antenna' is :
(A) inductive (B) capacitive
(C) resistive above its resonance frequency (D) none of the above

21. The Q of a resonant transimission line is :
(A) $Q = \frac{\omega}{LR}$ (B) $Q = \frac{\omega R}{L}$ (C) $Q = \frac{L}{R}$ (D) $Q = \frac{\omega L}{R}$

22. Range of frequencies allotted for commercial FM radio broadcast is -
(A) 88 to 108 MHz (B) 88 to 108 kHz (C) 8 to 88 MHz (D) 88 to 108 GHz

DPP No. : C16

Total Marks : 54	Max. Time : 36 min.	
Single choice Objective ('–1' negative marking) Q.1 to Q.11	(3 marks 2 min.)	[33, 22]
Assertion and Reason ('–1' negative marking) Q.12 to Q.18	(3 marks, 2 min.)	[21, 14]

1. The frequency of light wave in a material is 2×10^{14} Hz and wavelength is 5000 Å. The refractive index of material will be :
(A) 1.40 (B) 1.50 (C) 3.00 (D) 1.33

2. Which of the following is/are the limitations of amplitude modulation?
(A) Clear reception (B) High efficiency
(C) Small operating range (D) Good audio quality

3. Which is more advantageous ? (i) analog data communication (ii) digital data communication ?
(A) analog data communication (B) digital data communication
(C) both are equally good (D) depends on the situation

4. The attenuation in optical fibre is mainly due to
(A) Absorption (B) Scattering
(C) Neither absorption nor scattering (D) Both (A) and (B)

5. Which of the following four alternatives is not correct? **[AIEEE 2011, 11 May; 4/120, –1]**
We need modulation:
(A) to reduce the time lag between transmission and reception of the information signal
(B) to reduce the size of antenna
(C) to reduce the e fractional band width, that is the ratio of the signal band width to the centre frequency
(D) to increase the selectivity.

6. A radar has a power of 1kW and is operating at a frequency of 10 GHz. It is located on a mountain top of height 500m. The maximum distance upto which it can detect object located on the surface of the earth (Radius of earth = 6.4×10^6 m) is : **[AIEEE - 2012, 4/120, –1]**
(A) 80 km (B) 16 km (C) 40 km (D) 64 km

7. A diode detector is used to detect an amplitude modulated wave of 60% modulation by using a condenser of capacity 250 pico farad in parallel with a load resistance 100 kilo ohm. Find the maximum modulated frequency which could be detected by it. **[JEE (Main) - 2013; 4/120, –1]**
(A) 10.62 MHz (B) 10.62 kHz (C) 5.31 MHz (D) 5.31 kHz

8. If a carrier wave c(t) = A sinω_ct, were to be amplitude modulated by a modulating signal m(t) = A sinω_mt, the equation representing the modulated signal [C_m(t)], and its modulatgion index, would be respectively : **[JEE(MAIN) 2013_ONLINE TEST]**
(A) $C_m(t) = A(1 + \sin\omega_c t)\sin\omega_m t$ and 1
(B) $C_m(t) = A(1 + \sin\omega_c t)\sin\omega_m t$ and 2
(C) $C_m(t) = A(1 + \sin\omega_m t)\sin\omega_c t$ and 1
(D) $C_m(t) = A(1 + \sin\omega_m t)\sin\omega_c t$ and 2

9. A signal of 5 kHZ frequency is amplitude modulated on a carrier wave of frequency 2 mHz. The frequencies of the resultant signal is/are : **[JEE(Main)-2015; 4/120, –1]**
(A) 2 MHz only
(B) 2005 kHz, and 1995 kHz
(C) 2005 kHz, 2000 kHz and 1995 kHz
(D) 2000 kHz and 1995 kHz

10. Choose the correct statement : **[JEE(Main)-2016; 4/120, –1]**
(A) In amplitude modulation the frequency of high frequency carrier wave is made to vary in proportion to the amplitude of the audio signal
(B) In frequency modulation the amplitude of the high frequency carrier wave is made to vary in proportion to the amplitude of the audio signal.
(C) In frequency modulation the amplitude of the high frequency carrier wave is made to vary in proportion to the frequency of the audio signal
(D) In amplitude modulation the amplitude of the high frequency carrier wave is made to vary in proportion to the amplitude of the audio signal

11. In amplitude modulation, sinusoidal carrier frequency used is denoted by ω_c and the signal frequency is denoted by ω_m. The bandwidth ($\Delta\omega_m$) of the signal is such that $\Delta\omega_m << \omega_c$. Which of the following frequency is not contained in the modulated wave ? **[JEE Main 2017]**
(A) $\omega_c - \omega_m$
(B) ω_m
(C) ω_c
(D) $\omega_m + \omega_c$

12. **Statement -1 :** The electrical conuctivity of earth's atmosphere increases with altitude.
Statement - 2 : The high energy particles (i.e., γ-rays and cosmic rays) coming from outer space while entering our earth's atmosphere cause ionization of the atoms of the gases present in the atmosphere and their energy decreases as they approach to earth.'
(A) Statement-1 is True, Statement-2 is True; Statement-2 is a correct explanation for Statement-1.
(B) Statement-1 is True, Statement-2 is True; Statement-2 is NOT a correct explanation for Statement-1
(C) Statement-1 is True, Statement-2 is False
(D) Statement-1 is False, Statement-2 is True

13. **Statement–I:** Surface wave and sky wave can not be observed on moon.
Statement–II: Atmosphere of variable refractive index is require for propagation of surface & sky wave.
(A) Statement-1 is True, Statement-2 is True; Statement-2 is a correct explanation for Statement-1.
(B) Statement-1 is True, Statement-2 is True; Statement-2 is NOT a correct explanation for Statement-1
(C) Statement-1 is True, Statement-2 is False
(D) Statement-1 is False, Statement-2 is True

14. **Statement–I:** Diode lasers are used as optical sources in optical communication.
Statement–II: Diode lasers consume less energy.
(A) Statement-1 is True, Statement-2 is True; Statement-2 is a correct explanation for Statement-1.
(B) Statement-1 is True, Statement-2 is True; Statement-2 is NOT a correct explanation for Statement-1
(C) Statement-1 is True, Statement-2 is False
(D) Statement-1 is False, Statement-2 is True

15. **Statement–I:** Television signals are received through skywave propagation.
Statement–II: The ionosphere reflects electromagnetic waves of frequencies greater than a certain critical frequency.
(A) Statement-1 is True, Statement-2 is True; Statement-2 is a correct explanation for Statement-1.
(B) Statement-1 is True, Statement-2 is True; Statement-2 is NOT a correct explanation for Statement-1
(C) Statement-1 is True, Statement-2 is False
(D) Statement-1 is False, Statement-2 is True

16. **Statement–I:** In high latitude one sees colourful curtains of light hanging down from high altitudes.
Statement–II: The high energy charged particles from the sun are deflected to polar regions by the magnetic field of the earth.
(A) Statement-1 is True, Statement-2 is True; Statement-2 is a correct explanation for Statement-1.
(B) Statement-1 is True, Statement-2 is True; Statement-2 is NOT a correct explanation for Statement-1
(C) Statement-1 is True, Statement-2 is False
(D) Statement-1 is False, Statement-2 is True

17. **Statement–I:** Short wave bands are used for transmission of radio waves to a large distance.
Statement–II: Short waves are reflected by ionosphere.
(A) Statement-1 is True, Statement-2 is True; Statement-2 is a correct explanation for Statement-1.
(B) Statement-1 is True, Statement-2 is True; Statement-2 is NOT a correct explanation for Statement-1
(C) Statement-1 is True, Statement-2 is False
(D) Statement-1 is False, Statement-2 is True

18. This question has Statement –1 and Statement –2. Of the four choices given after the statements, choose the one that best describes the two statements. **[AIEEE - 2011, 4/120, –1]**
Statement –1
Sky wave signals are used for long distance radio communication. These signals are in general, less stable than ground wave signals.
Statement –2 :
The state of ionosphere varies from hour to hour, day to day and season to season.
(A) Statement –1 is true, statement –2 is false.
(B) Statement –1 is true, Statement –2 is true, Statement –2 is the correct explanation of Statement –1
(C) Statement –1 is true, Statement –2 is true, Statement –2 is not the correct explanation of Statement–1
(D) Statement–1 is false, Statement –2 is true

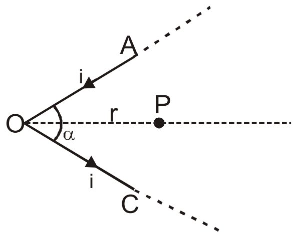
DPP No. : C17 (JEE-Advanced)

Total Marks : 39	**Max. Time : 30 min.**
Single choice Objective ('–1' negative marking) Q.1 to Q.2	**(3 marks, 2 min.) [06, 04]**
One or more than one options correct type ('–1' negative marking) Q.3 to Q.4	**(4 marks 2 min.) [08, 04]**
Comprehension ('–1' negative marking) Q.5 to Q.7	**(3 marks 2 min.) [09, 06]**
Subjective Questions ('–1' negative marking) Q.8 to Q.9	**(4 marks 5 min.) [08, 10]**
Match the Following (no negative marking) Q.10	**(8 marks, 6 min.) [08, 06]**

1. Two uniformly charged identical non-conducting rings of radius R are placed coaxially at separation of 2R. A uniformly charged non-conducting sphere of radius R is placed between rings such that its centre lies at the mid point of line joining the centres of two rings. Charge on ring 1 is Q. Electric field and potential is zero at centre of the sphere. What will be the potential at the centre of ring 2 ?

(A) $\frac{KQ}{R}(2-2\sqrt{2})$
(B) $\frac{KQ}{R}\left(1+\frac{1}{\sqrt{5}}-2\sqrt{2}\right)$
(C) $\frac{KQ}{R}\left(2-\frac{2\sqrt{2}}{2}\right)$
(D) $\frac{KQ}{R}\left(1+\frac{1}{\sqrt{5}}-\frac{2\sqrt{2}}{3}\right)$

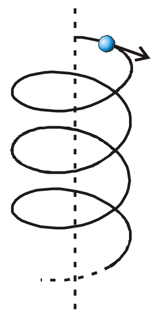
2. Two wires OA and OC carry equal currents i as shown in figure. One end of both the wires extends to infinity. Angle AOC is α. The magnitude of magnetic field at a point 'P' on the bisector of these two wires at a seperation r from point O is



(A) $\frac{\mu_0 i}{2\pi r}\cot\left(\frac{\alpha}{2}\right)$ (B) $\frac{\mu_0 i}{4\pi r}\cot\left(\frac{\alpha}{2}\right)$ (C) $\frac{\mu_0 i}{2\pi r}\frac{\left(1+\cos\frac{\alpha}{2}\right)}{\left(\sin\frac{\alpha}{2}\right)}$ (D) zero

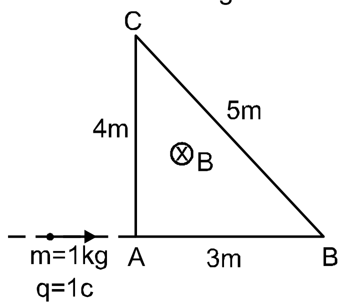
3. A tuning fork vibrate with a string then it paroduce 5 beat per sec. If tension in string slightly decrease then it again produce 5 beat per sec. If same tunning fork vibrate with an orgain pipe it produce 4 beat per sec. If temperature of air slightly increase then it produce 4 beat per sec with same organ pipe :
(A) If initially orgain pipe and string vibrate together then 9 beat per sec. produce by the system.
(B) If organ pipe and string produce sound after changes then 9 beat pers sec produce by the system
(C) If tension in string decrease and sounded with organ pipe without changing temperature then only 1 beat per sec. produce by the system (string + pipe)
(D) If tension in string remain same and temperature of air in organ pipe changes then only 1 beat per sec. produce by the system (string + pipe)

4. A very long uniform helix is made of thin metal wire. The axis of helix is vertical. A small bead begins to slide down the fixed helix starting from rest. Considering friction between bead and wire of helix to be nonzero, which of the following statements is/ are true as long as bead moves on helix.
(A) The speed of bead keeps on increasing.
(B) The magnitude of frictional force on bead remains constant.
(C) The speed of bead first increases and then remains constant.
(D) The magnitude of frictional force increases and then remains constant.



COMPREHENSION

A small particle of mass m = 1kg and charge of 1C enters perpendicularly in a triangular region of uniform magnetic field of strength 2T as shown in figure :



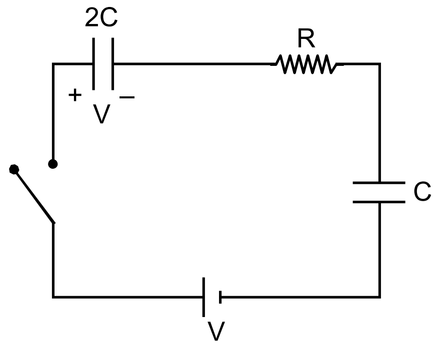
5. Calculate maximum velocity of the particle with which it should enter so that it complete a half–circle in magnetic region :
(A) 2 m/s (B) 2.5 m/s (C) 3 m/s (D) 4 m/s

6. In previous question, if particle enters perpendicularly with velocity 48 m/s in magnetic region. Then, how much time will it spend in magnetic region :
(A) $\frac{11\pi}{360}$ sec. (B) $\frac{7\pi}{360}$ sec. (C) $\frac{13\pi}{360}$ sec. (D) $\frac{17\pi}{360}$ sec.

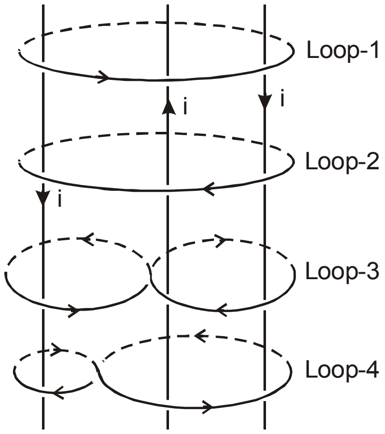
7. In the previous question find the chang e in angular momentum of particle w.r.t. centre of its circular path during its motion in magnetic field :
(A) 1152 kg.m^2/s (B) 576 kg.m^2/s (C) 2304 kg.m^2/s (D) zero

8. A meter bridge experiment is performed with a known resistance of 20 ohm. Balance point is at ℓ for an unknown resistor of value x ohm. Balance point shift to right by $\frac{1000}{63}$ cm when another resistor of value x ohm is combined parallel to unknown resistor. Balance point shift to left by $\frac{2000}{117}$ cm, when it is connected in series. If ℓ is $\frac{500}{A}$ cm then A is.

9. In the given figure switch is closed at some instant. Before this, capacitor of capacitance C is uncharged and 2C has potential V as shown. If total heat dissipated in resistor after switch is closed is x × CV^2 then x is.



10. Three wires are carrying same constant current i in different directions. Four loops enclosing the wires in different manners are shown. The direction of $d\vec{\ell}$ is shown in the figure :



	Column I	**Column II**
(A)	Along closed Loop-1	(p) $\oint \vec{B}.d\vec{\ell} = \mu_0 i$
(B)	Along closed Loop-2	(q) $\oint \vec{B}.d\vec{\ell} = -\mu_0 i$
(C)	Along closed Loop-3	(r) $\oint \vec{B}.d\vec{\ell} = 0$
(D)	Along closed Loop-4	(s) net work done by the magnetic force to move a unit charge along the loop is zero.

DPP No. : C18 (JEE-Advanced)

Total Marks : 41	**Max. Time : 33 min.**	
Single choice Objective ('–1' negative marking) Q.1 to Q.3	**(3 marks, 2 min.)**	**[09, 06]**
One or more than one options correct type (‘–1’ negative marking) Q.4 to Q.6	**(4 marks 2 min.)**	**[12, 06]**
Subjective Questions ('–1' negative marking) Q.7 to Q.9	**(4 marks 5 min.)**	**[12, 15]**
Match the Following (no negative marking) Q.10	**(8 marks, 6 min.)**	**[08, 06]**

1. A screw gauge with a pitch of 0.5 mm and a circular scale with 50 divisions is used to measure the thickness of a thin sheet of Aluminium. Before starting the measurement, it is found that when the two jaws of the screw gauge are brought in contact, the 45^{th} division coincides with the main scale line and that the zero of the main scale is barely visible. What is the thickness of the sheet if the main scale reading is 0.5mm and the 25^{th} division coincides with the main scale line ?

[JEE (Main) 2016; 4/120, –1]

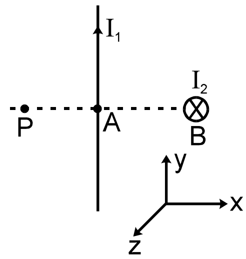
(A) 0.80 mm (B) 0.70mm (C) 0.50mm (D) 0.75mm

2. The following observations were taken for determining surface tension T of water by capillary method : diameter of capillary, D = 1.25×10^{-2} m rise of water , h = 1.45×10^{-2} m.

Using g = 9.80 m/s^2 and the simplified relation $T = \frac{rhg}{2} \times 10^3$ N/m, the possible error in surface tension is closest to : **[JEE (Main) 2017, 4/120, –1]**

(A) 10% (B) 0.15% (C) 1.5% (D) 2.4%

3. Two infinitely long linear conductors are arranged perpendicular to each other and are in mutually perpendicular planes as shown in figure. If I_1 = 2A along the y-axis and I_2 = 3A along –ve z-axis and AP = AB = 1 cm. The value of magnetic field strength $\vec{B}$ at P is



(A) $(3 \times 10^{-5}\ T)\ \hat{j} + (-4 \times 10^{-5}\ T)\ \hat{k}$

(B) $(3 \times 10^{-5}\ T)\ \hat{j} + (4 \times 10^{-5}\ T)\ \hat{k}$

(C) $(4 \times 10^{-5}\ T)\ \hat{j} + (3 \times 10^{-5}\ T)\ \hat{k}$

(D) $(-3 \times 10^{-5}\ T)\ \hat{j} + (4 \times 10^{-5}\ T)\ \hat{k}$

4. A particle perform SHM on a straight line with time period T and amplitude A. The average speed of the particle between two successive instants, when potential energy and kinetic energy become same is/are:

(A) $\frac{4\sqrt{2}\left(\sqrt{2}-1\right)\ A}{T}$ (B) $\frac{4\sqrt{2}\ A}{T}$ (C) 0 (D) none of these

5. A point charge of specific charge $\frac{q}{m}$ = 0.1 C/kg is projected in uniform magnetic field. The particle moves in magnetic field such that its position vector at any instant is given by $\vec{r} = 3\sin t\,\hat{i} + 3\cos t\,\hat{j} + 4t\hat{k}$.

Select correct statements from following :

(A) Magnetic field in space is 10T

(B) The distance traveled by the particle in 5s is 20m

(C) Power of magnetic force is zero

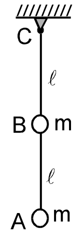
(D) The radius of curvature of the path is 3m

6. A simple pendulum is oscillating with small amplitude. The bob is given a positive charge and a uniform magnetic field is applied in a direction perpendicular to the plane of oscillations. Which of the following quantities will not be effected by the presence of magnetic field ?

(A) Amplitude of oscillations (B) Time period of oscillations

(C) Tension in the string at mean position (D) Tension in the string at extreme position

7. A weightless rod of length 2ℓ carries two equal masses 'm', one secured at lower end A and the other at the middle of the rod at B. The rod can rotate in vertical plane about a fixed horizontal axis passing through C. What horizontal velocity must be imparted to the mass at A so that it just completes the vertical circle.



8. A 40 kg mass, hanging at the end of a rope of length ℓ, oscillates in a vertical plane with an angular amplitude of θ_0. What is the tension in the rope, when it makes an angle θ with the vertical ? If the breaking strength of the rope is 80 kg f, what is the maximum angular amplitude θ with which the mass can oscillate without the rope breaking ?

9. A bird is singing on a tree and a man is hearing at a distance 'r' from the bird. then the displacement of the man towards the bird so that the loudness heard by man increases by 20 dB is $\frac{x}{y}r$ then find the minimum value of $x + y$ is [Assume that the motion of man is along the line joining the bird and the man]

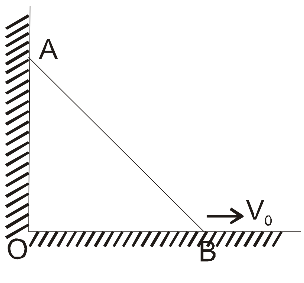
10. Regarding speed of sound in gas, match the statements in column-I with the results in column-II

Column I	Column II
(A) Temperature of gas is made 4 times and pressure 2 times	(p) speed becomes $2\sqrt{2}$ times the initial value
(B) Only pressure is made 4 times without change in temperature	(q) speed becomes 2 times the initial value
(C) Only temperature is changed to 4 times	(r) speed remains unchanged
(D) Only Molecular mass of the gas is made 4 times	(s) speed becomes half the initial value

DPP No. : C19 (JEE-Main)

Total Marks : 61		Max. Time : 40 min.
Single choice Objective ('–1' negative marking) Q.1 to Q.19	(3 marks, 2 min.)	[57, 38]
One or more than one options correct type ('–1' negative marking) Q.20	(4 marks 2 min.)	[04, 02]

1. Initially rod AB was vertical with end A in contact with wall. Now it's lower end starts slipping over the surface with constant speed V_0. If length of Rod is ℓ then rate at which area of ΔAOB will change. [consider duration in which A remain in contact with vertical wall]



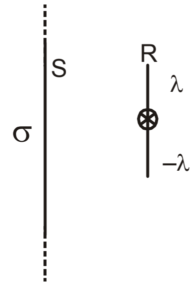
(A) $\frac{1}{2}\ V_0\left[\frac{\ell^2 - v_0^2t^2}{\sqrt{\ell^2 - 2v_0^2t^2}}\right]$

(B) $\frac{1}{2}\ V_0\left[\frac{\ell^2 - 2v_0^2t^2}{\sqrt{\ell^2 - v_0^2t^2}}\right]$

(C) $\frac{1}{2}\ V_0\left[\frac{\ell^2 - 3v_0^2t^2}{\sqrt{\ell^2 - 2v_0^2t^2}}\right]$

(D) $\frac{1}{2}\ V_0\left[\frac{\ell^2 - 2v_0^2t^2}{\sqrt{\ell^2 - 3v_0^2t^2}}\right]$

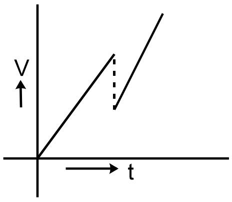
2. In the figure shown S is a large non-conducting sheet of uniform charge density σ. A rod R of length ℓ and uniformly distributed total mass ' m '. It is parallel to the sheet and hinged at its mid point. The linear charge densities on the upper and lower half are shown in the figure. The angular acceleration of the rod just after it is released is:

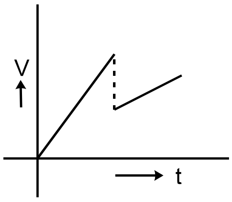


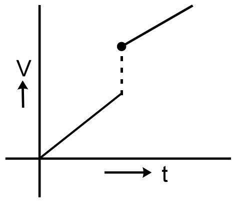
(A) $\frac{3\sigma\lambda}{m\epsilon_0}$ (B) $\frac{3\sigma\lambda}{2m\epsilon_0}$

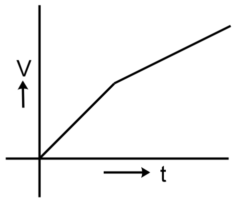
(C) $\frac{3\sigma\lambda}{8m\epsilon_0}$ (D) none of these

3. Two balls of same mass are released simultaneously from heights h & 2h from the ground level. The balls collide with the floor & stick to it. Then the velocity-time graph of centre of mass of the two balls is best represented by :

(A) 

(B) 

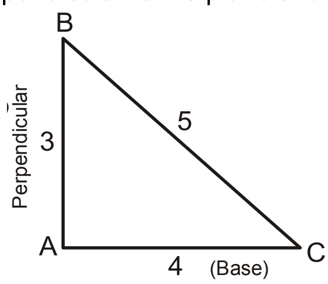
(C) 

(D) 

4. A system consists of two point masses, A and B of masses 1 kg and 2 kg respectively. At an instant the kinetic energy of A with respect to the centre of mass is 2 Joules and the velocity of centre of mass is 2 m/s. The kinetic energy of the system at this instant is :

(A) 9 J (B) 11 J (C) 13 J (D) none of these

5. Moment of inertia of uniform triangular plate about axis passing through sides AB, AC, BC are I_P, I_B & I_H respectively & about an axis perpendicular to the plane and passing through point C is I_C. Then :



(A) $I_C > I_P > I_B > I_H$ (B) $I_H > I_B > I_C > I_P$ (C) $I_P > I_H > I_B > I_C$ (D) none of these

6. A particle is performing SHM with acceleration a = 8 π^2 – 4 π^2 x where x is coordinate of the particle w.r.t. the origin. The parameters are in S.I. units. The particle is at rest at x = –2 at t = 0.

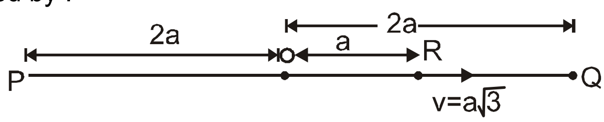
(A) coordinate of the particle w.r.t. origin at any time t is 2 – 4 cos2π t

(B) coordinate of the particle w.r.t. origin at any time t is –2 + 4 sin2πt

(C) coordinate of the particle w.r.t. origin at any time t is – 4 + 2 cos2πt

(D) the coordinate cannot be found because mass of the particle is not given.

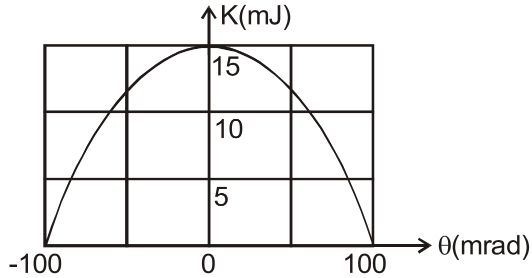
7. A particle of mass m is performing SHM along line PQ with amplitude 2a with mean position at O. At t = 0 particle is at point R(OR = a) and is moving towards Q with velocity v = $a\sqrt{3}$ m/sec. The equation can be expressed by :



(A) x = a $(\sqrt{3}\sin t + \cos t)$ (B) x = 2a$(\sqrt{3}\sin t + \cos t)$

(C) x = 2a$(\sin t + \sqrt{3}\cos t)$ (D) x = a$(\sin t + \sqrt{3}\cos t)$

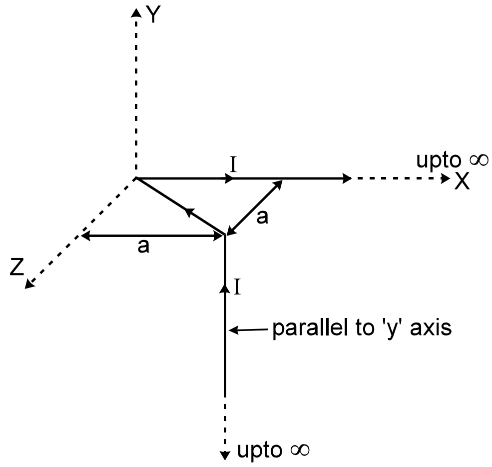
8. Figure shows the kinetic energy K of a simple pendulum versus its angle θ from the vertical. The pendulum bob has mass 0.2 kg. The length of the pendulum is equal to ($g = 10\ m/s^2$).



(A) 2.0 m (B) 1.8 m (C) 1.5 m (D) 1.2 m

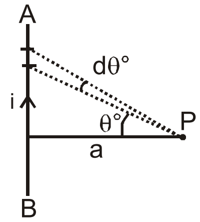
9. An object moves vertically with simple harmonic motion just behind a wall. From the other side of the wall the object is visible in each cycle for 2.0s and hidden behind the wall for 6.0s The maximum height reached by the object relative to the top of the wall is 0.3 m. The amplitude of the motion is :
(A) 0.5 m (B) 0.6 m (C) 1.0 m (D) 1.2 m

10. The magnetic field at the origin due to the current flowing in the wire is



(A) $-\dfrac{\mu_0 I}{8\pi a}(\hat{i}+\hat{k})$ (B) $\dfrac{\mu_0 I}{2\pi a}(\hat{i}+\hat{k})$ (C) $\dfrac{\mu_0 I}{8\pi a}(-\hat{i}+\hat{k})$ (D) $\dfrac{\mu_0 I}{4\pi a\sqrt{2}}(\hat{i}-\hat{k})$

11. Consider a straight wire AB carrying a current i from B to A.Consider a small segment of this wire which subtends a small angle $d\theta$ (in degrees) at the point P as shown in the figure.The magnetic field produced by this small segment at the point P is: (current i is in ampere,a is in metres and the angles in degrees)



(A) $\dfrac{\mu_0 i\cos\theta\, d\theta}{720\, a}$ (B) $\dfrac{\mu_0 i\sin\theta\, d\theta}{4\pi a}$ (C) $\dfrac{\mu_0 i\sin\theta\, d\theta}{72a}$ (D) $\dfrac{\mu_0}{4\pi}\dfrac{i\cos\theta}{a}d\theta$

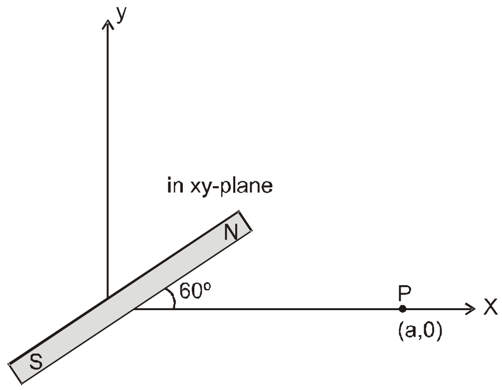
12. Which of the following demonstrated that earth has a magnetic field ?
(A) Intensity of cosmic rays (stream of charged particle comingfrom outer space) is more at the poles than at the equator.
(B) Earth is surrounded by an ionosphere (a shell of charged particles)
(C) Earth is a planet rotating about the north south axis
(D) Large quantity of iron ore is found in the earth

13. If the earth's field induction at a place is 0.36 gauss and the angle of dip is 60^0. Then the horizontal and vertical component of the field is :

(A) $0.36\,\text{gauss},\ 0.36\sqrt{3}\,\text{gauss}$ (B) $0.18\,\text{gauss},\ 0.18\sqrt{3}\,\text{gauss}$

(C) $0.09\,\text{gauss},\ 0.09\sqrt{3}\,\text{gauss}$ (D) none of these

14. A magnet of dipole moment M placed at origin as shown in figure. Then select correct alternative about Magnetic field produced by it:



(A) $\frac{\mu_0}{8\pi}\frac{\sqrt{7}M}{a^3}$, at angle $\phi = 30^o$ with x-axis

(B) $\frac{\mu_0}{8\pi}\frac{\sqrt{7}M}{a^3}$, at angle $\phi = 60^o$ with x-axis

(C) $\frac{\mu_0}{4\pi}\frac{\sqrt{5}M}{a^3}$, at angle $\phi = \tan^{-1}\left(\frac{\sqrt{3}}{2}\right)$ with x-axis

(D) $\frac{\mu_0}{8\pi}\frac{\sqrt{7}M}{a^3}$, at angle $\phi = \tan^{-1}\left(\frac{\sqrt{3}}{2}\right)$ with x-axis

15. The magnetic induction and the intensity of magnetic field inside an iron pole of an electromagnetic are 10 Wb m^{-2} and 250 Am^{-1} respectively. What is the relative permeability of iron ? ($\mu_0 = 4\pi \times 10^{-7}\ Hm^{-1}$)

(A) $\frac{10^5}{6\pi}$ (B) $\frac{10^5}{\pi}$ (C) $\frac{10^5}{3\pi}$ (D) $\frac{10^5}{5\pi}$

16. **STATEMENT–1 :** Two charged particles are released from rest in gravity free space. After some time, one particle will exert a non-zero magnetic force on the other particle in addition to electrostatic force.
STATEMENT–2: A moving charge produces magnetic field. Also a magnetic force may act on a charged particle moving in an external magnetic field.

(A) Statement-1 is True, Statement-2 is True; Statement-2 **is** a correct explanation for Statement-1
(B) Statement-1 is True, Statement-2 is True; Statement-2 **is NOT** a correct explanation for Statement–1
(C) Statement-1 is True, Statement-2 is False
(D) Statement-1 is False, Statement-2 is True.

17. The dimensional formula of magnetic flux density is :

(A) $[M^1 L^2 T^1 I^{-1}]$ (B) $[M^1 T^{-2} I^{-1}]$ (C) $[M^1 L^2 T^{-2} I^{-1}]$ (D) $[M^1 L^1 T^{-2} I^{-1}]$

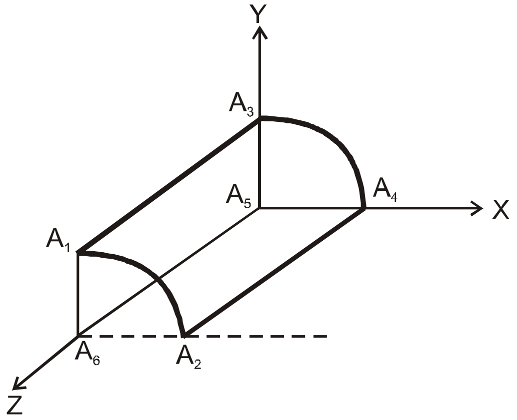
18. The magnetic flux ϕ through a metal ring varies with time t according to :

$$\phi = 3(at^3 - bt^2)Tm^2, \text{ with } a = 2s^{-3} \text{ and } b = 6\ s^{-2}.$$

The resistance of the ring is 3 Ω. The maximum current induced in the ring during the interval t = 0 to t = 2s, is

(A) 1 A (B) 2A (C) 3A (D) 6 A

19. A time varying magnetic field, $(\vec{B} = B_0 t\hat{k})$, is confined in a cylindrical region and is cutting the xy plane on a circle $x^2 + y^2 = 4$ where x and y are in meters. A wire frame A_1 A_2 A_4 A_3 A_1 is placed in the magnetic field as shown. Segment A_1 A_2 and A_3 A_4 are identical quarter circles parallel to each other with axis along z-axis. The induced current flowing in the wire frame is equal to : (The total length of the loop of wire frame is 10m, radius of arc A_3 A_4 and arc A_1 A_2 is 1m each and resistance per unit length is 1Ω/m)



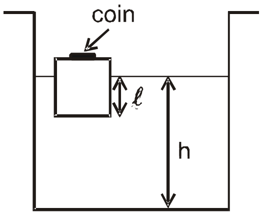
(A) zero (B) $\frac{B_0\pi}{10}$ (C) $\frac{B_0\pi}{5}$ (D) $\frac{B_0\pi}{20}$

20. Which of the following statements are true ?
(A) The angle of dip at 30° of north is the same as that of 60° of south.
(B) The angle of dip at the equator is 0°.
(C) The angle of dip on the magnetic north pole of the earth is 90°.
(D) The angle of dip on the magnetic south pole of the earth is 90°.

DPP No. : C20 (JEE-Advanced)

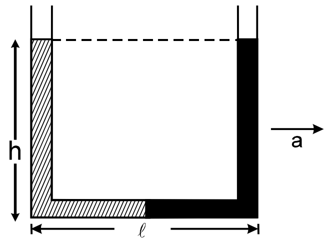
Total Marks : 59	**Max. Time : 38 min.**
Single choice Objective ('–1' negative marking) Q.1 to Q.3	**(3 marks, 2 min.) [09, 06]**
One or more than one options correct type ('–1' negative marking) Q.4 to Q.7	**(4 marks 2 min.) [16, 08]**
Comprehension ('–1' negative marking) Q.8 to Q.13	**(3 marks 2 min.) [18, 12]**
Match the Following (no negative marking) Q.14 to Q.15	**(8 marks, 6 min.) [16, 12]**

1. A wooden block with a coin placed on its top, floats in water as shown in figure. The distance ℓ and h are shown here. After some time the coin falls into the water. Then :



(A) ℓ decreases and h increase (B) ℓ increases and h decreases
(C) both ℓ and h increases (D) both ℓ and h decrease

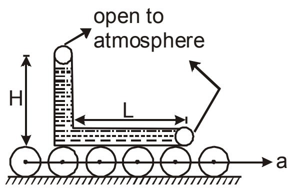
2. A U-tube of base length "ℓ" filled with same volume of two liquids of densities ρ and 2ρ is moving with an acceleration "a" on the horizontal plane as shown in the figure. If the height difference between the two surfaces (open to atmosphere) becomes zero, then the height h is given by:



(A) $\frac{a}{2g}\ell$ (B) $\frac{3a}{2g}\ell$

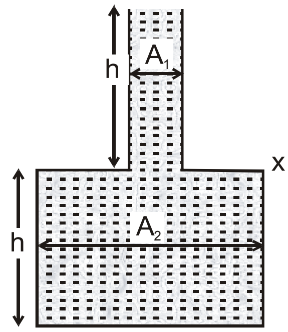
(C) $\frac{a}{g}\ell$ (D) $\frac{2a}{3g}\ell$

3. A narrow tube completely filled with a liquid is lying on a series of cylinders as shown in figure. Assuming no sliding between any surfaces, the value of acceleration of the cylinders for which liquid will not come out of the tube from anywhere is given by



(A) $\frac{gH}{2L}$ (B) $\frac{gH}{L}$ (C) $\frac{2gH}{L}$ (D) $\frac{gH}{\sqrt{2}L}$

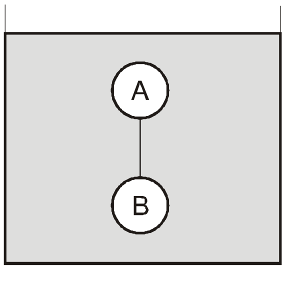
4. The vessel shown in Figure has two sections of area of cross-section A_1 and A_2. A liquid of density ρ fills both the sections, up to height h in each. Neglecting atmospheric pressure,



(A) the pressure at the base of the vesel is $2h\rho g$
(B) the weight of the liquid in vessel is equal to $2h\rho gA_2$
(C) the force exerted by the liquid on the base of vessel is $2h\rho gA_2$
(D) the walls of the vessel at the level X exert a force $h\rho g(A_2 - A_1)$ downwards on the liquid.

5. A cubical block of wood of edge 10cm and mass 0.92kg floats on a tank of water with oil of rel. density 0.6. Thickness of oil is 4cm above water. When the block attains equilibrium with four of its sides edges vertical:
(A) 1 cm of it will be above the free surface of oil.
(B) 5 cm of it will be under water.
(C) 2 cm of it will be above the common surface of oil and water.
(D) 8 cm of it will be under water.

6. Two solid spheres A and B of equal volumes but of different densities d_A and d_B are connected by a string. They are fully immersed in a fluid of density d_F. They get arranged into an equilibrium state as shown in the figure with a tension in the string. The arrangement is possible only if



(A) $d_A < d_F$ (B) $d_B > d_F$ (C) $d_A > d_F$ (D) $d_A + d_B = 2d_F$

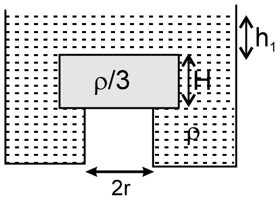
7*. A solid sphere of radius R and density ρ is attached to one end of a mass-less spring of force constant k. The other end of the spring is connected to another solid sphere of radius R and density 3ρ. The complete arrangement is placed in a liquid of density 2ρ and is allowed to reach equilibrium. The correct statement(s) is (are) **[JEE (Advanced)-2013, 3/60, –1]**

(A) the net elongation of the spring is $\frac{4\pi R^3 \rho g}{3k}$ (B) the net elongation of the spring is $\frac{8\pi R^3 \rho g}{3k}$

(C) the light sphere is partially submerged. (D) the light sphere is completely submerged.

COMPREHENSION–1

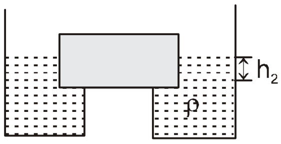
A wooden cylinder of diameter 4r, height H, density $\frac{\rho}{3}$ is kept on a hole of diameter 2r of a tank, filled with liquid of density ρ as shown in figure.



8. If level of the liquid starts decreasing slowly when the level of liquid is at a height h_1 above the cylinder the block starts moving up. At what value of h_1, will the block rise :

(A) $\frac{4H}{9}$ (B) $\frac{5H}{9}$ (C) $\frac{5H}{3}$ (D) Remains same

9. The block in the above question is maintained at the position by external means and the level of liquid is lowered. The height h_2 when this external force reduces to zero is **[IIT-JEE 2006 , 5/184]**



(A) $\frac{4H}{9}$ (B) $\frac{5H}{9}$ (C) Remains same (D) $\frac{2H}{3}$

10. If height h_2 of water level is further decreased then, **[IIT-JEE 2006 , 5/184]**

(A) cylinder will not move up and remains at its original position.

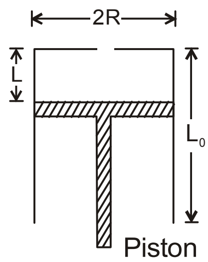
(B) for $h_2 = H/3$, cylinder again starts moving up

(C) for $h_2 = H/4$, cylinder again starts moving up

(D) for $h_2 = H/5$ cylinder again starts moving up

COMPREHENSION–2 **[IIT-JEE 2007, 4×3/184]**

A fixed thermally conducting cylinder has a radius R and height L_0. The cylinder is open at its bottom and has a small hole at its top. A piston of mass M is held at a distance L from the top surface, as shown in the figure. The atmospheric pressure is P_0.



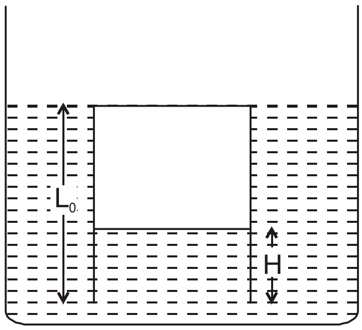
11. The piston is now pulled out slowly and held at a distance 2L from the top. The pressure in the cylinder between its top and the piston will then be

(A) P_0 (B) $\frac{P_0}{2}$ (C) $\frac{P_0}{2}+\frac{Mg}{\pi R^2}$ (D) $\frac{P_0}{2}-\frac{Mg}{\pi R^2}$

12. While the piston is at a distance 2L from the top, the hole at the top is sealed. The piston is then released, to a position where it can stay in equilibrium. In this condition, the distance of the piston from the top is

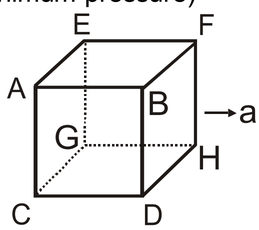
(A) $\left(\frac{2P_0\pi R^2}{\pi R^2 P_0 + Mg}\right)(2L)$ (B) $\left(\frac{P_0\pi R^2 - Mg}{\pi R^2 P_0}\right)(2L)$ (C) $\left(\frac{P_0\pi R^2 + Mg}{\pi R^2 P_0}\right)(2L)$ (D) $\left(\frac{P_0\pi R^2}{\pi R^2 P_0 - Mg}\right)(2L)$

13. The piston is taken completely out of the cylinder. The hole at the top is sealed. A water tank is brought below the cylinder and put in a position so that the water surface in the tank is at the same level as the top of the cylinder as shown in the figure. The density of the water is ρ. In equilibrium, the height H of the water column in the cylinder satisfies



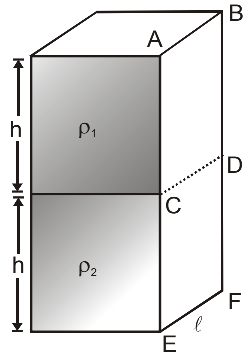
(A) $\rho g (L_0 - H)^2 + P_0 (L_0 - H) + L_0P_0 = 0$
(B) $\rho g (L_0 - H)^2 - P_0 (L_0 - H) - L_0P_0 = 0$
(C) $\rho g (L_0 - H)^2 + P_0 (L_0 - H) - L_0P_0 = 0$
(D) $\rho g (L_0 - H)^2 - P_0 (L_0 - H) + L_0P_0 = 0$

14. A cubical box is completely filled with mass m of a liquid and is given horizontal acceleration a as shown in the figure. Match the force due to fluid pressure on the faces of the cube with their appropriate values (assume zero pressure as minimum pressure)



	Column I	**Column II**
(A)	force on face ABFE	(p) $\frac{ma}{2}$
(B)	force on face BFHD	(q) $\frac{mg}{2}$
(C)	force on face ACGE	(r) $\frac{ma}{2}+\frac{mg}{2}$
(D)	force on face CGHD	(s) $\frac{ma}{2}$ +mg
		(t) $\frac{mg}{2}$ + ma

15. A cuboid is filled with liquid of density ρ_2 upto height h & with liquid of density ρ_1 , also upto height h as shown in the figure



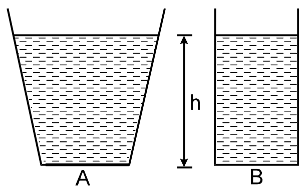
	Column I	**Column II**
(A)	Force on face ABCD due to liquid of density ρ_1	(p) zero
(B)	Force on face ABCD due to liquid of density ρ_2	(q) $\frac{\rho_1 gh^2\ell}{2}$
(C)	Force on face CDEF transferrred due to liquid of density ρ_1	(r) $\rho_1 gh^2\ell$
(D)	Force on face CDEF due to liquid of density ρ_2 only	(s) $\frac{\rho_2 gh^2\ell}{2}$

DPP No. : C21 (JEE-Main)

Total Marks : 60	**Max. Time : 40 min.**
Single choice Objective ('–1' negative marking) Q.1 to Q.20	**(3 marks 2 min.) [60, 40]**

1. A tank with length 10 m, breadth 8 m and depth 6m is filled with water to the top. If g = 10 m s^{-2} and density of water is 1000 kg m^{-3}, then the thrust on the bottom is (neglect atmospheric pressure)
(A) 6 × 1000 × 10 × 80 N (B) 3 × 1000 × 10 × 48 N
(C) 3 × 1000 × 10 × 60 N (D) 3 × 1000 × 10 × 80 N

2. Two vessels A and B of different shapes have the same base area and are filled with water up to the same height h (see figure). The force exerted by water on the base is F_A for vessel A and F_B for vessel B. The respective weights of the water filled in vessels are W_A and W_B. Then

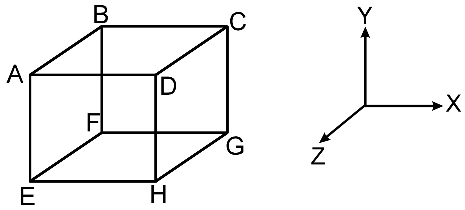


(A) $F_A > F_B$; $W_A > W_B$ (B) $F_A = F_B$; $W_A > W_B$
(C) $F_A = F_B$; $W_A < W_B$ (D) $F_A > F_B$; $W_A = W_B$

3.(i) The cubical container ABCDEFGH which is completely filled with an ideal (nonviscous and incompressible) fluid, moves in a gravity free space with an acceleration of

$$a = a_0(\hat{i} - \hat{j} + \hat{k})$$

where a_0 is a positive constant. Then the only point in the container shown in the figure where pressure is maximum, is



(A) B (B) C (C) E (D) F

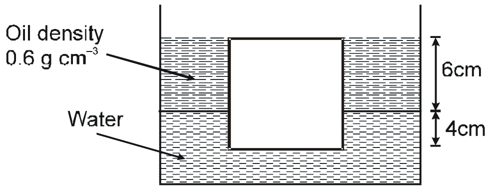
(ii) In previous question pressure will be minimum at point –
(A) A (B) B (C) H (D) F

4. The density of ice is x gm/cc and that of water is y gm/cc. What is the change in volume in cc, when m gm of ice melts?
(A) M (y – x) (B) (y – x)/m (C) mxy (x – y) (D) m (1/y – 1/x)

5. The reading of a spring balance when a block is suspended from it in air is 60 newton. This reading is changed to 40 newton when the block is fully submerged in water. The specific gravity of the block must be therefore :
(A) 3 (B) 2 (C) 6 (D) 3/2

6. Two bodies are in equilibrium when suspended in water from the arms of a balance. The mass of one body is 36 g and its density is 9 g/cc. If the mass of the other is 48 g, its density in g/cc is :
(A) 4/3 (B) 3/2 (C) 3 (D) 5

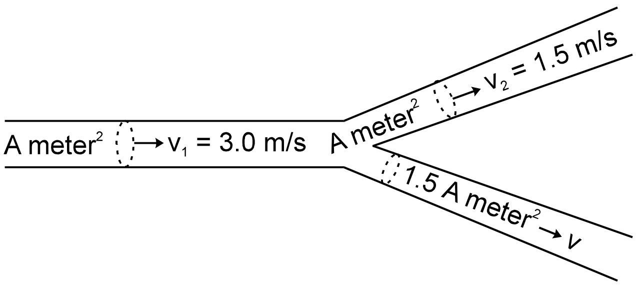
7. A cubical block of wood 10 cm on a side, floats at the interface of oil and water as shown in figure. The density of oil is 0.6 g cm^{-3} and density of water is 1 g cm^{-3}. The mass of the block is



(A) 706 g (B) 607 g (C) 760 g (D) 670 g

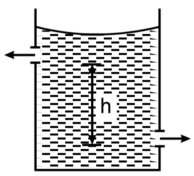
8. A fixed cylindrical vessel is filled with water up to height H. A hole is bored in the wall at a depth h from the free surface of water. For maximum horizontal range h is equal to :
(A) H (B) 3H/4 (C) H/2 (D) H/4

9. An incompressible liquid flows through a horizontal tube as shown in the figure. Then the velocity ' v ' of the fluid is :



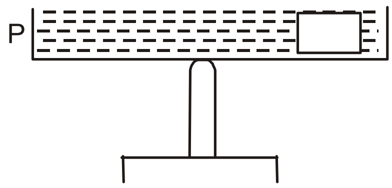
(A) 3.0 m/s (B) 1.5 m/s (C) 1.0 m/s (D) 2.25 m/s

10. There are two identical small holes on the opposite sides of a tank containing a liquid. The tank is open at the top. The difference in height of the two holes is h as shown in the figure. As the liquid comes out of the two holes, the tank will experience a net horizontal force proportional to:



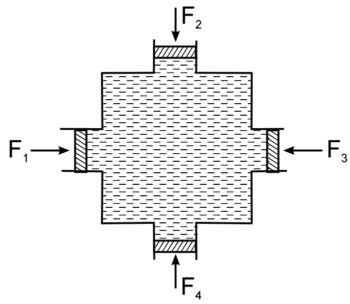
(A) $h^{1/2}$ (B) h (C) $h^{3/2}$ (D) h^2

11. An open pan P filled with water (density ρ_w) is placed on a vertical rod, maintaining equilibrium. A block of density ρ is placed on one side of the pan as shown in the figure. Water depth is more than height of the block.



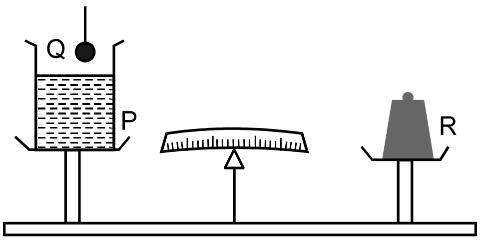
(A) Equilibrium will be maintained only if $\rho < \rho_W$.
(B) Equilibrium will be maintained only if $\rho \le \rho_W$.
(C) Equilibrium will be maintained for all relations between ρ and ρ_W .
(D) It is not possible to maintain the equilibrium

12. In the figure shown water is filled in a symmetrical container. Four pistons of equal area A are used at the four opening to keep the water in equilibrium. Now an additional force F is applied at each piston. The increase in the pressure at the centre of the container due to this addition is :



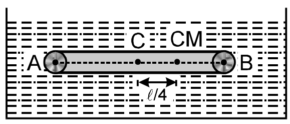
(A) $\frac{F}{A}$ (B) $\frac{2F}{A}$
(C) $\frac{4F}{A}$ (D) 0

13. Figure shows a weighing-bridge, with a beaker P with water on one pan and a balancing weight R on the other. A solid ball Q is hanging with a thread outside water. It has volume 40 cm^3 and weighs 80 g. If this solid is lowered to sink fully in water, but not touching the beaker anywhere, the balancing weight R' will be



(A) same as R (B) 40 g less than R (C) 40 g more than R (D) 80 g more than R

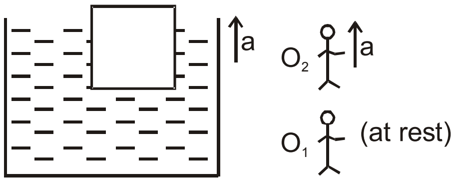
14. A non uniform cylinder of mass m, length ℓ and radius r is having its centre of mass at a distance $\ell/4$ from the centre and lying on the axis of the cylinder as shown in the figure. The cylinder is kept in a liquid of uniform density ρ. The moment of inertia of the rod about the centre of mass is I. The angular acceleration of point A relative to point B just after the rod is released from the position shown in figure is :



(A) $\frac{\pi\rho g\ell^2 r^2}{I}$ (B) $\frac{\pi\rho g\ell^2 r^2}{4I}$ (C) $\frac{\pi\rho g\ell^2 r^2}{2I}$ (D) $\frac{3\pi\rho g\ell^2 r^2}{4I}$

15. A liquid is kept in a cylindrical vessel which is rotated about its axis. The liquid rises at the sides. If the radius of the vessel is 0.05 m and the speed of rotation is 2 rev/s, The difference in the height of the liquid at the centre of the vessel and its sides will be ($\pi^2 = 10$) :
(A) 3 cm (B) 2 cm (C) 3/2 cm (D) 2/3 cm

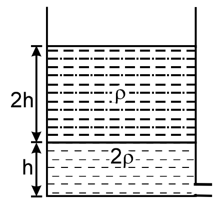
16. A block is partially immersed in a liquid and the vessel is accelerating upwards with an acceleration "a". The block is observed by two observers O_1 and O_2 , one at rest and the other accelerating with an acceleration "a" upward as shown in the figure. The total buoyant force on the block is :



(A) same for O_1 and O_2
(B) greater for O_1 than O_2
(C) greater for O_2 than O_1
(D) data is not sufficient

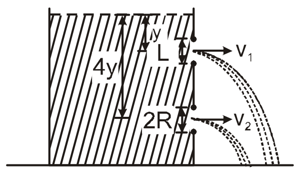
17. There is a small hole in the bottom of a fixed container containing a liquid upto height 'h'. The top of the liquid as well as the hole at the bottom are exposed to atmosphere. Area of the hole is 'a' and that of the top surface is 'A'. As the liquid comes out of the hole then, :
(A) the top surface of the liquid accelerates with acceleration = g
(B) the top surface of the liquid accelerates with acceleration $= g\frac{a^2}{A^2}$
(C) the top surface of the liquid retards with retardation $= g\frac{a}{A}$
(D) the top surface of the liquid retards with retardation $= \frac{ga^2}{A^2}$

18. The velocity of the liquid coming out of a small hole of a large vessel containing two different liquids of densities 2ρ and ρ as shown in figure is



(A) $\sqrt{6gh}$
(B) $2\sqrt{gh}$
(C) $2\sqrt{2gh}$
(D) $\sqrt{gh}$

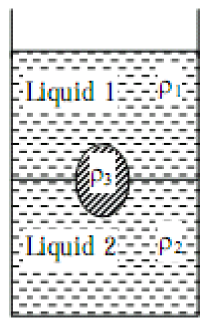
19. A large open tank has two holes in the wall. One is a square hole of side L at a depth y from the top and the other is a circular hole of radius R at a depth 4y from the top. When the tank is completely filled with water, the quantities of water flowing out per second from both holes are the same. Then radius R, is equal to :



[JEE - 2000, 2/105]

(A) $\frac{L}{\sqrt{2\pi}}$
(B) $2\pi L$
(C) L
(D) $\frac{L}{2\pi}$

20. A jar is filled with two non-mixing liquids 1 and 2 having densities ρ_1 and ρ_2, respectively. A solid ball, made of a material of density ρ_3, is dropped in the jar. It comes to equilibrium in the position shown in the figure.
Which of the following is true for ρ_1, ρ_2 and ρ_3 ?



(A) $\rho_1 > \rho_3 > \rho_2$
(B) $\rho_1 < \rho_2 < \rho_3$
(C) $\rho_1 < \rho_3 < \rho_2$
(D) $\rho_3 < \rho_1 < \rho_2$

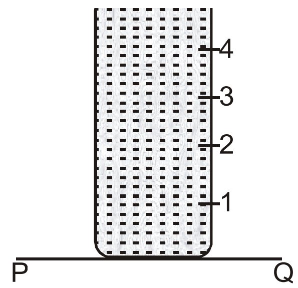
DPP No. : C22 (JEE-Main)

Total Marks : 48		Max. Time : 35 min.
Single choice Objective ('–1' negative marking) Q.1	(3 marks 2 min.)	[03, 02]
One or more than one options correct type ('–1' negative marking) Q.2	(4 marks 2 min.)	[04, 02]
Comprehension ('–1' negative marking) Q.3 to Q.9	(3 marks 2 min.)	[21, 14]
Subjective Questions ('–1' negative marking) Q.10	(4 marks 5 min.)	[04, 05]
Match the Following (no negative marking) Q.11 to Q.12	(8 marks 6 min.)	[16, 12]

1. A cylindrical tank of height 0.4 m is open at the top and has a diameter 0.16 m. Water is filled in it up to a height of 0.16 m. How long it will take to empty the tank through a hole of radius 5×10^{-3} m at its bottom ?

(A) 46.26 sec. (B) 4.6 sec. (C) 462.6 sec. (D) 0.46 sec.

2. A cylindrical vessel of 90 cm height is kept filled upto the brim as shown in the figure. It has four holes 1, 2, 3, 4 which are respectively at heights of 20cm, 30 cm, 40 cm and 50 cm from the horizontal floor PQ. The water falling at the maximum horizontal distance from the vessel comes from :

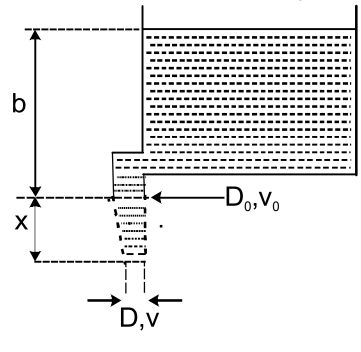


(A) hole number 4 (B) hole number 3 (C) hole number 2 (D) hole number 1.

COMPREHENSION # 1

The figure shows the commonly observed decrease in diameter of a water stream as it falls from a tap. The tap has internal diameter D_0 and is connected to a large tank of water. The surface of the water is at a height b above the end of the tap.

By considering the dynamics of a thin "cylinder" of water in the stream answer the following: (Ignore any resistance to the flow and any effects of surface tension, given ρ_w = density of water)



3. Equation for the flow rate, i.e. the mass of water flowing through a given point in the stream per unit time, as function of the water speed v will be

(A) $v\,\rho_w\,\pi D^2/4$ (B) $v\,\rho_w(\pi D^2/4 - \pi D_0^2/4)$

(C) $v\,\rho_w\,\pi D^2/2$ (D) $v\,\rho_w\,\pi D_0^2/4$

4. Which of the following equation expresses the fact that the flow rate at the tap is the same as at the stream point with diameter D and velocity v (i.e. D in terms of D_0 , v_0 and v will be) :

(A) $D = \frac{D_0 v_0}{v}$ (B) $D = \frac{D_0 v_0^2}{v^2}$ (C) $D = \frac{D_0 v}{v_0}$ (D) $D = D_0\sqrt{\frac{v_0}{v}}$

5. The equation for the water speed v as a function of the distance x below the tap will be :

(A) $v = \sqrt{2gb}$ (B) $v = [2g(b + x)]^{1/2}$ (C) $v = \sqrt{2gx}$ (D) $v = [2g(b - x)]^{1/2}$

6. Equation for the stream diameter D in terms of x and D_0 will be :

(A) $D = D_0\left(\frac{b}{b+x}\right)^{1/4}$ (B) $D = D_0\left(\frac{b}{b+x}\right)^{1/2}$

(C) $D = D_0\left(\frac{b}{b+x}\right)$ (D) $D = D_0\left(\frac{b}{b+x}\right)^{2}$

7. A student observes after setting up this experiment that for a tap with D_0 = 1 cm at x = 0.3 m the stream diameter D = 0.9 cm. The heights b of the water above the tap in this case will be :

(A) 5.7 cm (B) 57 cm (C) 27 cm (D) 2.7 cm

COMPREHENSION

A spray gun is shown in the figure where a piston pushes air out of a nozzle. A thin tube of uniform cross section is connected to the nozzle. The other end of the tube is in a small liquid container. As the piston pushes air through the nozzle, the liquid from the container rises into the nozzle and is sprayed out. For the spray gun shown, the radii of the piston and the nozzle are 20 mm and 1mm respectively. The upper end of the container is open to the atmosphere.

8. If the piston is pushed at a speed of 5 mms^{-1} , the air comes out of the nozzle with a speed of

[JEE (Advanced)-2014, 3/60, –1]

(A) $0.1ms^{-1}$ (B) $1ms^{-1}$ (C) $2ms^{-1}$ (D) $8ms^{-1}$

9. If the density of air is ρ_a and that of the liquid ρ_ℓ, then for a given piston speed the rate (volume per unit time) at which the liquid is sprayed will be proportional to

[JEE (Advanced)-2014, 3/60, –1]

(A) $\sqrt{\frac{\rho_a}{\rho_\ell}}$ (B) $\sqrt{\rho_a\rho_\ell}$ (C) $\sqrt{\frac{\rho_\ell}{\rho_a}}$ (D) ρ_ℓ

10. A large open top container of negligible mass and uniform cross–sectional area A has a small hole of cross–sectional area $\frac{A}{100}$ in its side wall near the bottom. The container is kept on a smooth horizontal floor and contains a liquid of density ρ and mass m_0. Assuming that the liquid starts flowing out horizontally through the hole at t = 0, The acceleration of the container is $\frac{x}{10}$ m/s^2 than x is -

11. **Column II** shows five systems in which two objects are labelled as X and Y. Also in each case a point P is shown. **Column I** gives some statements about X and and/or Y. Match these statements to the appropriate system(s) from **Column II.** **[IIT-JEE 2009, 8/160]**

Column I

(A) The force exerted by X on Y has a magnitude Mg.

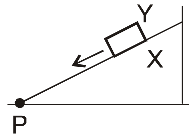
(B) The gravitational potential energy of X is continuously increasing,

(C) Mechanical energy of the system X + Y is continuously decreasing.

(D) The torque of the weight of Y about point P is zero.

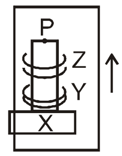
Column I

(p)



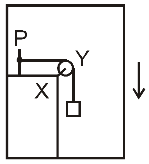
Block Y of mass M left on a fixed inclined plane X, slides on it with a constant velocity.

(q)



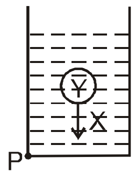
Two ring magnets Y and Z, each of mass M, are kept in frictionless vertical plastic stand so that they repel each other. Y rests on the base X and Z hangs in air in equilibrium. P is the topmost point of the stand on the common axis of the two rings. The whole system is in a lift that is going up with a constant velocity.

(r)



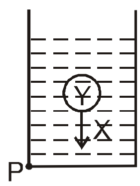
A pulley Y of mass m_0 is fixed to a table through a clamp X. A block of mass M hangs from a string that goes over the pulley and is fixed at point P of the table. The whole system is kept in a lift that is going down with a constant velocity.

(s)



A sphere Y of mass M is put in a nonviscous liquid X kept in a container at rest. The sphere is released and it moves down in the liquid.

(t)



A sphere Y of mass M is falling with its terminal velocity in a viscous liquid X kept in a container.

12. A person in a lift is holding a water jar, which has a small hole at the lower end of its side. When the lift is at rest, the water jet coming out of the hole hits the floor of the lift at a distance d = 1.2 m from the person. In the following, state of the lift's motion is given in List - I and the distance where the water jet hits the floor of the lift is given in List - II. Match the statements from List - I with those in List- II and select the correct answer using the code given below the lists. **[JEE (Advanced)-2014, 3/60, –1]**

	List -I	List -II
P.	Lift is accelerating vertically up.	**1.** d = 1.2 m
Q.	Lift is accelerating vertically down with an acceleration less than the gravitational acceleration.	**2.** d > 1.2m
R.	List is moving vertically up with constant Speed	**3.** d < 1.2 m
S.	Lift is falling freely.	**4.** No water leaks out of the jar

Code :
(A) P-2, Q-3, R-2, S-4 (B) P-2, Q-3, R-1, S-4
(C) P-1, Q-1, R-1, S-4 (D) P-2, Q-3, R-1, S-1

DPP No. : C23 (JEE-Main)

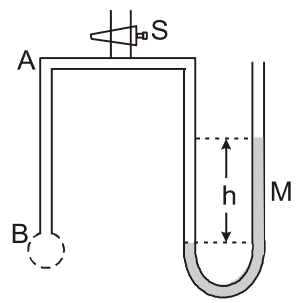
Total Marks : 66		**Max. Time : 44 min.**
Single choice Objective ('–1' negative marking) Q.1 to Q.22	**(3 marks 2 min.)**	**[66, 44]**

1. The surface tension of a liquid is 5 Newton per metre. If a film is held on a ring of area 0.02 metres^2, its surface energy is about :
(A) 5×10^{-2} J (B) 2.5×10^{-2} J (C) 2×10^{-1} J (D) 3×10^{-1} J

2. The radii of the two columns is U-tube are r_1 and r_2. When a liquid of density ρ (angle of contact is 0°) is filled in it, the level difference of liquid in two arms is h. The surface tension of liquid is : (g = acceleration due to gravity) :
(A) $\frac{\rho g h r_1 r_2}{2(r_2 - r_1)}$ (B) $\frac{\rho g h(r_2 - r_1)}{2r_1 r_2}$ (C) $\frac{2(r_2 - r_1)}{\rho g h r_1 r_2}$ (D) $\frac{\rho g h}{2(r_2 - r_1)}$

3. Water rises in a capillary tube to a height h. it will rise to a height more than h
(A) on the surface of sun (B) in a lift moving down with an acceleration
(C) at the poles (D) in a lift moving up with an acceleration.

4. A tube of fine bore AB is connected to a manometer M as shown. The stop cock S controls the flow of air. AB is dipped into a liquid whose surface tension is σ. On opening the stop cock for a while, a bubble is formed at B and the manometer level is recorded, showing a difference h in the levels in the two arms. if ρ be the density of manometer liquid and r the radius of curvature of the bubble, then the surface tension σ of the liquid is given by



(A) ρhrg (B) $2\rho hgr$ (C) $4\rho hrg$ (D) $\frac{rh\rho g}{4}$

5. Two parallel glass plates are dipped partly in the liquid of density 'd'. keeping them vertical. If the distance between the plates is 'x', Surface tension for liquid is T & angle of contact is θ then rise of liquid between the plates due to capillary will be :
(A) $\frac{T\cos\theta}{x\ \ d}$ (B) $\frac{2T\cos\theta}{xdg}$ (C) $\frac{2T}{xdg\cos\theta}$ (D) $\frac{T\cos\theta}{xdg}$

6. When charge is given to a soap bubble, it shows :
(A) a decrease in size
(B) no change in size
(C) an increase in size
(D) sometimes an increase and sometimes a decreases in size

7. An air bubble of radius r in water is at a depth h below the water surface at some instant. If P is atmospheric pressure, d and T are density and surface tension of water respectively, the pressure inside the bubble will be :
(A) $P + h\,dg - \frac{4T}{r}$ (B) $P + h\,dg + \frac{2T}{r}$ (C) $P + h\,dg - \frac{2T}{r}$ (D) $P + h\,dg + \frac{4T}{r}$

8. The work done to get n smaller equal size spherical drops from a bigger size spherical drop of water is proportional to :
(A) $\left(\frac{1}{n^{2/3}}\right) - 1$ (B) $\left(\frac{1}{n^{1/3}}\right) - 1$ (C) $n^{1/3} - 1$ (D) $n^{4/3} - 1$

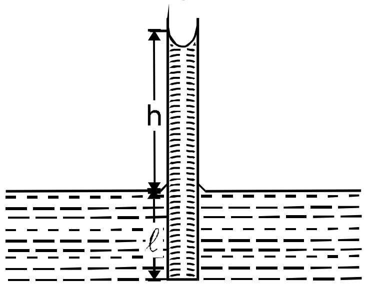
9. Two unequal soap bubbles are formed one on each side of a tube closed in the middle by a tap. What happens when the tap is opened to put the two bubbles in communication ?
(A) No air passes in any direction as the pressures are the same on two sides of the tap
(B) Larger bubble shrinks and smaller bubble increases in size till they become equal in size
(C) Smaller bubble gradually collapses and the bigger one increases in size
(D) None of the above

10. A soap bubble in vacuum has a radius of 3 cm and another soap bubble in vacuum has a radius of 4 cm. If the two bubbles coalesce under isothermal conditions then the radius of the new bubble is :
(A) 2.3 cm (B) 4.5 cm (C) 5 cm (D) 7 cm

11. A cylinder with a movable piston contains air under a pressure p_1 and a soap bubble of radius 'r'. The pressure p_2 to which the air should be compressed by slowly pushing the piston into the cylinder for the soap bubble to reduce its size by half will be : (The surface tension is σ, and the temperature T is maintained constant)
(A) $\left[8p_1 + \frac{24\sigma}{r}\right]$ (B) $\left[4p_1 + \frac{24\sigma}{r}\right]$ (C) $\left[2p_1 + \frac{24\sigma}{r}\right]$ (D) $\left[2p_1 + \frac{12\sigma}{r}\right]$

12. A capillary tube of radius R is immersed in water and water rises in it to a height H. Mass of water in capillary tube is M. If the radius of the tube is doubled, mass of water that will rise in capillary tube will be :
(A) 2M (B) M (C) $\frac{M}{2}$ (D) 4M

13. Water rises to a height h in a capillary tube lowered vertically into water to a depth ℓ as shown in the figure. The lower end of the tube is now closed, the tube is then taken out of the water and opened again. The length of the water column remaining in the tube will be :

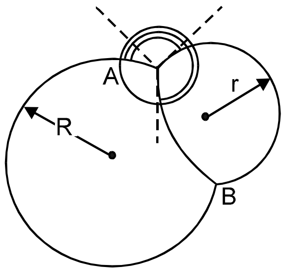


(A) 2h if $\ell > h$ and $\ell + h$ if $\ell < h$ (B) h if $\ell > h$ and $\ell + h$ if $\ell < h$
(C) 4h if $\ell > h$ and $\ell - h$ if $\ell < h$ (D) h/2 if $\ell > h$ and $\ell + h$ if $\ell < h$

14. A soap bubble of radius r_1 is placed on another soap bubble of radius $r_2(r_1 < r_2)$. The radius R of the soapy film separating the two bubbles is :

(A) $r_1 + r_2$ (B) $\sqrt{r_1^2 + r_2^2}$ (C) $(r_1^3 + r_2^3)$ (D) $\frac{r_2 r_1}{r_2 - r_1}$

15. A soap - bubble with a radius 'r' is placed on another bubble with a radius R (figure). Angles between the films at the points of contact will be –



(A) 120^0 (B) 30^0 (C) 45^0 (D) 90^0

16. A large number of liquid drops each of radius 'a' coalesce to form a single spherical drop of radius 'b'. The energy released in the process is converted into kinetic energy of the big drop formed. The speed of big drop will be :

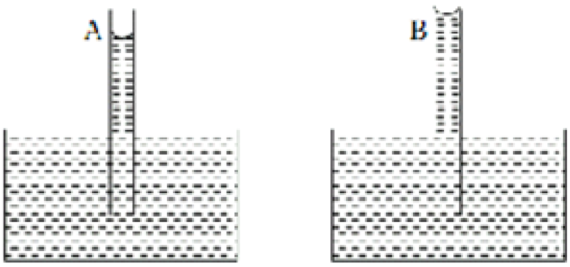
(A) $\sqrt{\frac{6T}{\rho}\left[\frac{1}{a}-\frac{1}{b}\right]}$ (B) $\sqrt{\frac{4T}{\rho}\left[\frac{1}{a}-\frac{1}{b}\right]}$ (C) $\sqrt{\frac{8T}{\rho}\left[\frac{1}{a}-\frac{1}{b}\right]}$ (D) $\sqrt{\frac{5T}{\rho}\left[\frac{1}{a}-\frac{1}{b}\right]}$

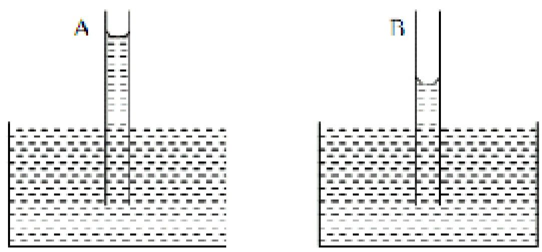
17. At critical temperature, the surface tension of a liquid :

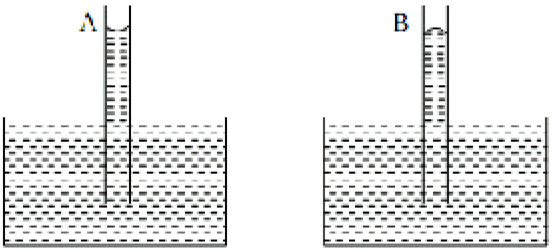
(A) is zero (B) is infinity
(C) is same as that at any other temperature (D) cannot be determined

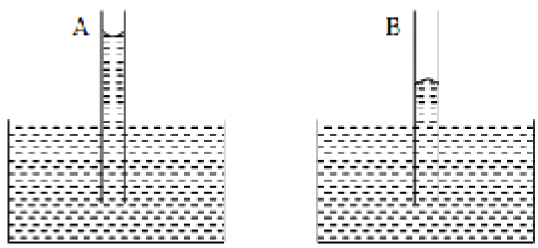
18. A capillary tube (A) is dipped in water. Another identical tube (B) is dipped in a soap-water solution. Which of the following shows the relative nature of the liquid columns in the two tubes ?

[AIEEE 2008, 4/120, –1]

(A)


(B)


(C)


(D)


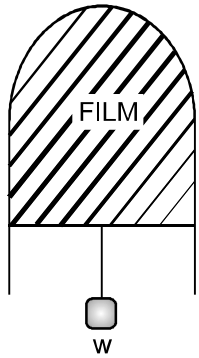
19. Work done in increasing the size of a soap bubble from a radius of 3 cm to 5 cm is nearly. (Surface tension of soap solution = 0.03 Nm^{-1}) **[AIEEE - 2011, 4/120, –1]**

(A) 4π mJ (B) 0.2π mJ (C) 2π mJ (D) 0.4π mJ

20. Two mercury drops (each of radius ' r') merge to from bigger drop. The surface energy of the bigger drop , if T is the surface tension, is : **[AIEEE 2011, 4/120, –1]**

(A) $4\pi r^2$ T (B) $2\pi r^2$ T (C) $2^{8/3}\pi r^2$ T (D) $2^{5/3}\pi r^2$ T

21. A thin liquid film formed between a U-shaped wire and a light slider supports a weight of 1.5×10^{-2} N (see figure). The length of the slider is 30 cm and its weight negligible. The surface tension of the liquid film is : **[AIEEE 2012, 4/120, –1]**



(A) 0.0125 Nm^{-1} (B) 0.1 Nm^{-1} (C) 0.05 Nm^{-1} (D) 0.025 Nm^{-1}

22. Assume that a drop of liquid evaporates by decrease in its surface energy, so that its temperature remains unchanged. What should be the minimum radius of the drop for this to be possible ? The surface tension is T, density of liquid is ρ and L is its latent heat of vaporization.

(A) $\rho L/T$ (B) $\sqrt{T/\rho L}$ (C) $T/\rho L$ (D) $2T/\rho L$

DPP No. : C24

Total Marks : 41	Max. Time : 42 min.	
Single choice Objective ('–1' negative marking) Q.1	(3 marks 2 min.)	[03, 02]
Comprehension ('–1' negative marking) Q.2 to Q.3	(3 marks 2 min.)	[06, 04]
Subjective Questions ('–1' negative marking) Q.4 to Q.9	(4 marks 5 min.)	[24, 30]
Match the Following (no negative marking) Q.10	(8 marks 6 min.)	[08, 06]

1. There is a horizontal film of soap solution. On it a thread is placed in the form of a loop. The film is punctured inside the loop and the thread becomes a circular loop of radius R. If the surface tension of the soap solution be T, then the tension in the thread will be :

(A) $\pi R^2/T$ (B) $\pi R^2 T$ (C) $2\pi RT$ (D) $2RT$

COMPREHENSION # 1

The internal radius of one limb of a capillary U-tube is r_1 = 1 mm and the internal radius of the second limb is r_2 = 2 mm. The tube is filled with some mercury, and one of the limbs is connected to a vacuum pump. The surface tension & density of mercury are 480 dyn/cm & 13.6 gm/cm^3 respectively. (assume contact angle to be $\theta = 180^\circ$) ($g = 9.8\ m/s^2$)

2. What will be the difference in air pressure when the mercury levels in both limbs are at the same height ?

(A) 3.53 mm of Hg (B) 1.51 mm of Hg
(C) 0.51 mm of Hg (D) 5.52 mm of Hg

3. Which limb of the tube should be connected to the pump ?

(A) Limb having radius 2 mm (B) Limb having radius 1mm
(C) Any of the limb (D) None of these

4. A mercury drop of radius 1.0 cm is sprayed into 10^6 droplets of equal size. Calculate the energy expanded. (Surface tension of mercury = 32×10^{-2} N/m).

5. A film of water is formed between two straight parallel wires each 10 cm long and at separation 0.5 cm. Calculate the work required to increase 1 mm distance between wires. Surface tension = 72×10^{-3} N/m.

6. A soap bubble has radius R and surface tension S, How much energy is required to double the radius without change of temperature.

7. Find the excess pressure inside a drop of mercury of radius 2 mm, a soap bubble of radius 4 mm and an air bubble of radius 4 mm formed inside a tank of water. Surface tension of mercury is 0.465 N/m and soap solution and water are, 0.03 N/m and 0.076 N/m respectively.

8. There is a soap bubble of radius 2.4×10^{-4} m in air cylinder which is originally at the pressure 10^5 N/m^2. The air in the cylinder is now compressed isothermally until the radius of the bubble is halved . Calculate now the pressure (in atm) of air in the cylinder. The surface tension of the soap solution is 0.08 N/m

9. Two soap bubbles A and B are kept in a closed chamber where the air is maintained at pressure 8 N/m^2. The radii of bubbles A and B are 2cm and 4cm, respectively. Surface tension of the soap-water used to make bubbles is 0.04 N/m. Find the ratio n_B/n_A, where n_A and n_B are the number of moles of air in bubbles A and B, respectively. [Neglect the effect of gravity.] **[IIT 2009_4/160, –1]**

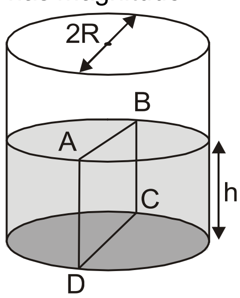
10.

Column - I	Column - II
(A) Spliting of brigger drop into small drops	(P) Temperature changes
(B) Formation of bigger drop from small drops.	(Q) Temprerature remain constant
(C) Spraying of liquid	(R) Surface energy changes
(D) Spliting of bigger soap bubble into small soap bubble of same thickness	(S) Surface energy remain unchange

DPP No. : C25

Total Marks : 50	**Max. Time : 40 min.**	
Single choice Objective ('–1' negative marking) Q.1 to Q.3	**(3 marks 2 min.)**	**[09, 06]**
One or more than one options correct type ('–1' negative marking) Q.4 to Q.7	**(4 marks 2 min.)**	**[16, 08]**
Comprehension ('–1' negative marking) Q.8 to Q.10	**(3 marks 2 min.)**	**[09, 06]**
Subjective Questions ('–1' negative marking) Q.11 to Q.14	**(4 marks 5 min.)**	**[16, 20]**

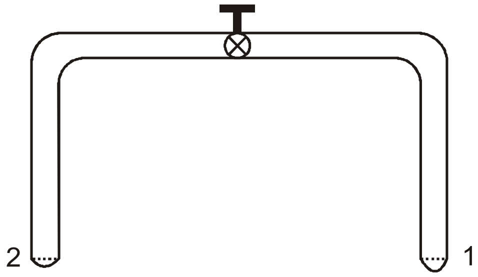
1. Water is filled up to a height h in a beaker of radius R as shown in the figure. The density of water is ρ, the surface tension of water is T and the atmospheric pressure is P_0. Consider a vertical section ABCD of the water column through a diameter of the beaker. The force on water on one side of this section by water on the other side of this section has magnitude **[JEE 2007, 3/184]**



(A) $|2P_0Rh + \pi R^2\rho gh - 2RT|$ (B) $|2P_0Rh + R\rho gh^2 - 2RT|$

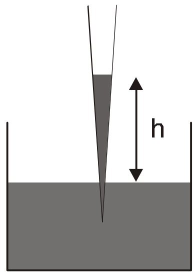
(C) $|P_0\pi R^2 + R\rho gh^2 - 2RT|$ (D) $|P_0\pi R^2 + R\rho gh^2 + 2RT|$

2. A glass tube of uniform internal radius (r) has a valve separating the two identical ends. Initially, the valve is in a tightly closed position. End 1 has a hemispherical soap bubble of radius r. End 2 has sub-hemispherical soap bubble as shown in figure. Just after opening the valve, **[JEE -2008 3/163, –1]**
Figure :



(A) air from end 1 flows towards end 2. No change in the volume of the soap bubbles
(B) air from end 1 flows towards end 2. Volume of the soap bubble at end 1 decreases
(C) no change occurs
(D) air from end 2 flows towards end 1. Volume of the soap bubble at end 1 increases.

3. A glass capillary tube is of the shape of a truncated cone with an apex angle α so that its two ends have cross sections of different radii. When dipped in water vertically, water rises in it to a height h, where the radius of its cross section is b. If the surface tension of water is S, its density is ρ, and its contact angle with glass is θ, the value of h will be (g is the acceleration due to gravity)
[JEE (Advanced)-2014, 3/60, –1]



(A) $\frac{2S}{b\rho g}\cos(\theta-\alpha)$ (B) $\frac{2S}{b\rho g}\cos(\theta+\alpha)$ (C) $\frac{2S}{b\rho g}\cos(\theta-\alpha/2)$ (D) $\frac{2S}{b\rho g}\cos(\theta+\alpha/2)$

4. When a capillary tube is immersed into a liquid, the liquid neither rises nor falls in the capillary ?
(A) The angle of contact must be 90^0
(B) The angle of contact may be 90^0
(C) The surface tension of liquid must be zero
(D) The surface tension of liquid may be zero

5. Angle of contact between a liquid and a solid is a property of :
(A) the material of liquid
(B) the material of solid
(C) the mass of the solid
(D) the shape of the solid

6. If a liquid rises to same height in two capillaries of same material at same tempreture then.
(A) Weight of liquid in both capillaries will be equal
(B) Radius of miniscus will be equal
(C) For this capillaries must be curve and vertical.
(D) Hydrostatic pressure at the bare of capillaries must be same.

7. Suppose outside pressure is P_0 and surface tension of soapwater solution is T and we are blowing a soap bubble of radius R. Then
(A) Pressure inside soap babble of radius R will be $P_0 + \frac{4T}{R}$.
(B) Pressure inside soap bubble of radius R will be $P_0 + \frac{2T}{R}$
(C) work done by external agent to blow soap bubble is equal to summation of work done against increase pressure from P_0 to (P_0 + $\frac{4T}{R}$) and work done against increase in surface energy.
(D) None of these

COMPREHENSION

When liquid medicine of density ρ is to be put in the eye, it is done with the help of a dropper. As the bulb on the top of the dropper is pressed, a drop forms at the opening of the dropper. We wish to estimate the size of the drop. We first assume that the drop formed at the opening is spherical because that requires a minimum increase in its surface energy. To determine the size, we calculate the net vertical force due to the surface tension T when the radius of the drop is R. When this force becomes smaller than the weight of the drop, the drop gets detached from the dropper.

8. If the radius of the opening of the dropper is r; the vertical force due to the surface tension on the drop of radius R (assuming r << R) is : **[IIT 2010; 3/163, –1]**

(A) $2\pi rT$ (B) $2\pi RT$ (C) $\frac{2\pi r^2 T}{R}$ (D) $\frac{2\pi R^2 T}{r}$

9. If $r = 5 \times 10^{-4}$ m, $\rho = 10^3$ kgm^{-3}, g = 10 ms^{-2}, T = 0.11 Nm^{-1}, the radius of the drop when it detaches from the dropper is approximately : **[IIT 2010; 3/163, –1]**

(A) 1.4×10^{-3} m (B) 3.3×10^{-3} m (C) 2.0×10^{-3} m (D) 4.1×10^{-3} m

10. After the drop detaches, its surface energy is : **[IIT 2010; 3/163, –1]**

(A) 1.4×10^{-6} J (B) 2.7×10^{-6} J (C) 5.4×10^{-6} J (D) 8.1×10^{-6} J

11. Two identical soap bubbles each of radius r and of the same surface tension T combine to form a new soap bubble of radius R. The two bubbles contain air at the same temperature. If the atmospheric pressure is p_0 then find the surface tension T of the soap solution in terms of p_0, r and R. Assume process is isothermal.

12. A spherical drop of water has 1mm radius. If the surface tension of the water is 50×10^{-3} N/m, then find the difference of pressure between inside and outside the spherical drop is :

13. The end of a capillary tube with a radius r is immersed into water. What amount of heat will be evolved when the water rises in the tube ? If surface tension of water 'T' density of water = ρ. Given $\frac{T^2}{\rho g} = \frac{2}{\pi}$

14. A soap bubble of radius ' r ' and surface tension ' T ' is given a potential of ' V ' volt . If the new radius ' R ' of the bubble is related to its initial radius by equation ,
$P_0 [R^3 - r^3] + \lambda T [R^2 - r^2] - \varepsilon_0 V^2 R/2 = 0$, where P_0 is the atmospheric pressure . Then find λ

DPP No. : C26

Total Marks : 44	Max. Time : 35 min.	
Single choice Objective ('–1' negative marking) Q.1 to Q.4	(3 marks 2 min.)	[12, 08]
One or more than one options correct type ('–1' negative marking) Q.5 to Q.6	(4 marks 2 min.)	[08, 04]
Comprehension ('–1' negative marking) Q.7 to Q.10	(3 marks 2 min.)	[12, 08]
Subjective Questions ('–1' negative marking) Q.11 to Q.13	(4 marks 5 min.)	[12, 15]

1. If a rubber ball is taken at the depth of 200 m in a pool its volume decreases by 0.1%. If the density of the water is 1×10^3 kg/m^3 and g = 10 m/s^2, then the volume elasticity in N/m^2 will be :

(A) 10^8 (B) 2×10^8 (C) 10^9 (D) 2×10^9

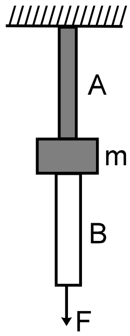
2. Two wires of the same material and length but diameter in the ratio 1 : 2 are stretched by the same force. The ratio of potential energy per unit volume for the two wires when stretched will be :

(A) 1 : 1 (B) 2 : 1 (C) 4 : 1 (D) 16 : 1

3. One end of a horizontal thick copper wire of length 2L and radius 2R is welded to an end of another horizontal thin copper wire of length L and radius R. When the arrangement is stretched by a applying forces at two ends, the ratio of the elongation in the thin wire to that in the thick wire is :
[JEE-Advanced-2013, 3/60,–1]
(A) 0.25 (B) 0.50 (C) 2.00 (D) 4.00

4. A tiny spherical oil drop carrying a net charge q is balanced in still air with a vertical uniform electric field of strength $\frac{81\pi}{7}\times 10^5$ Vm^{-1}. When the field is switched off, the drop is observed to fall with terminal velocity 2×10^{-3} m s^{-1}. Given g = 9.8 m s^{-2}, viscosity of the air = 1.8×10^{-5} Ns m^{-2} and the density of oil = 900 kg m^{-3}, the magnitude of q is : **[JEE 2010, 5/237, –2]**
(A) 1.6×10^{-19} C (B) 3.2×10^{-19} C (C) 4.8×10^{-19} C (D) 8.0×10^{-19} C

5. The wires A and B shown in the figure, are made of the same material and have radii r_A and r_B . A block of mass m kg is tied between them : If the force F is mg/3, one of the wires breaks.



(A) A will break before B if $r_A < 2r_B$
(B) A will break before B if $r_A = r_B$
(C) Either A or B will break if $r_A = 2r_B$
(D) The lengths of A and B must be known to decide which wire will break

6. A metal wire of length L area of cross-section A and Young's modulus Y is stretched by a variable force F such that F is always slightly greater than the elastic force of resistance in the wire. When the elongation of the wire is ℓ :
(A) the work done by F is $\frac{YA^2}{L}$
(B) the work done by F is $\frac{YA\ell^2}{2L}$
(C) the elastic potential energy stored in the wire is $\frac{YA\ell^2}{2L}$
(D) heat is produced during the elongation

COMPREHENSION # 1
When a tensile or compressive load 'P' is applied to rod or cable, its length changes. The change in length x which, for an elastic material is proportional to the force (Hook's law).
$P \propto x$ or P = kx
The above equation is similar to the equation of spring. For a rod of length L, area A and young modulus Y, the extension x can be expressed as -

$$x = \frac{PL}{AY} \quad \text{or} \quad P = \frac{AY}{L}x, \quad \text{hence } K = \frac{AY}{L}$$

Thus rods or cables attached to lift can be treated as springs. The energy stored in rod is called strain energy & equal to $\frac{1}{2}$ Px. The loads placed or dropped on the floor of lift cause stresses in the cables and can be evaluated by spring analogy. If the cable of lift is previously stressed and load is placed or dropped, then maximum extension in cable can be calculated by energy conservation.

7. If rod of length 4 m, area $4cm^2$ and young modulus 2×10^{10} N/m^2 is attached with mass 200 kg, then angular frequency of SHM (rad/sec.) of mass is equal to -
(A) 1000 (B) 10 (C) 100 (D) 10π

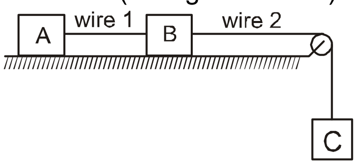
8. In above problem if mass of 10 kg falls on the massless collar attached to rod from the height of 99cm then maximum extension in the rod is equal (g = 10 m/sec^2) -
(A) 9.9 cm (B) 10 cm (C) 0.99 cm (D) 1 cm

9. In the above problem, the maximum stress developed in the rod is equal to - (N/m^2)
(A) 5×10^7 (B) 5×10^8 (C) 4×10^7 (D) 4×10^8

10. If two rods of same length (4m) and cross section areas 2 cm^2 and 4 cm^2 with same young modulus 2×10^{10} N/m^2 are attached one after the other with mass 600 kg then angular frequency is -
(A) $\frac{1000}{3}$ (B) $\frac{10}{3}$ (C) $\frac{100}{3}$ (D) $\frac{10\pi}{3}$

11. A 0.1 kg mass is suspended from a wire of negligible mass. The length of the wire is 1m and its cross-sectional area is 4.9×10^{-7} m^2. If the mass is pulled a little in the vertically downward direction and released, it performs simple harmonic motion of angular frequency 140 rad s^{-1}. If the Young's modulus of the material of the wire is n × 10^9 Nm^{-2}, the value of n is : **[JEE 2010, 3/252]**

12. Three blocks A, B and C each of mass 4 kg are attached as shown in figure. Both the wires has equal cross sectional area 5×10^{-7} m^2 . The surface is smooth. Find the longitudinal strain in each wire if Young modulus of both the wires is 2×10^{11} N/m^2 (take g = 10 m/s^2)



13. Consider two solid spheres P and Q each of density 8 gm cm^{-3} and diameters 1 cm and 0.5 cm, respectively. Sphere P is dropped into a liquid of density 0.8 gm cm^{-3} and viscosity η = 3 poiseulles. Sphere Q is dropped into a liquid of density 1.6 gm cm^{-3} and viscosity η = 2 poiseulles. The ratio of the terminal velocities of P and Q is : **[JEE Advanced 2016]**

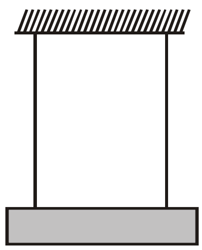
DPP No. : C27

Total Marks : 60	Max. Time : 40 min.
Single choice Objective ('–1' negative marking) Q.1 to Q.20	(3 marks 2 min.) [60, 40]

1. The diameter of a brass rod is 4 mm and Young's modulus of brass is 9×10^{10} N/m^2. The force required to stretch it by 0.1% of its length is :
(A) $360\,\pi$ N (B) 36 N (C) $144\,\pi \times 10^3$ N (D) $36\,\pi \times 10^5$ N

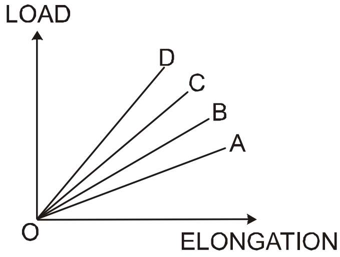
2. A steel wire is suspended vertically from a rigid support. When loaded with a weight in air, it expands by L_a and when the weight is immersed completely in water, the extension is reduced to L_w. Then relative density of the material of the weight is
(A) $\frac{L_a}{L_a - L_w}$ (B) $\frac{L_w}{L_a}$ (C) $\frac{L_a}{L_w}$ (D) $\frac{L_w}{L_a - L_w}$

3. Two wires of equal length and cross-section area suspended as shown in figure. Their Young's modulus are Y_1 and Y_2 respectively. The equivalent Young's modulus will be



(A) $Y_1 + Y_2$ (B) $\frac{Y_1 + Y_2}{2}$
(C) $\frac{Y_1 Y_2}{Y_1 + Y_2}$ (D) $\sqrt{Y_1 \quad Y_2}$

4. The load versus elongation graph for four wires of the same materials is shown in the figure. The thinnest wire is represented by the line :



(A) OC
(B) OD
(C) OA
(D) OB

5. A square brass plate of side 1.0 m and thickness 0.005 m is subjected to a force F on its smaller opposite edges, causing a displacement of 0.02 cm. If the shear modulus of brass is 0.4×10^{11} N/m^2, the value of the force F is
(A) 4×10^3 N (B) 400 N (C) 4×10^4 N (D) 1000 N

6. A metal block is experiencing an atmospheric pressure of 1×10^5 N/m^2, when the same block is placed in a vacuum chamber, the fractional change in its volume is (the bulk modulus of metal is 1.25×10^{11} N/m^2)
(A) 4×10^{-7} (B) 2×10^{-7} (C) 8×10^{-7} (D) 1×10^{-7}

7. If the potential energy of a spring is V on stretching it by 2 cm, then its potential energy when it is stretched by 10 cm will be :
(A) V/25 (B) 5 V (C) V/5 (D) 25 V

8. If work done in stretching a wire by 1mm is 2J, the work necessary for stretching another wire of same material, but with double the radius and half the length by 1mm in joule is -
(A) 1/4 (B) 4 (C) 8 (D) 16

9. An oil drop falls through air with a terminal velocity of 5×10^{-4} m/s.
(i) the radius of the drop will be :
(A) 2.5×10^{-6} m (B) 2×10^{-6} m (C) 3×10^{-6} m (D) 4×10^{-6} m
(ii) the terminal velocity of a drop of half of this radius will be : (Viscosity of air $= \frac{18 \times 10^{-5}}{5}$ N-s/m^2, g = 10 m/s^2, density of oil = 900 Kg/m^3. Neglect density of air as compared to that of oil)
(A) 3.25×10^{-4} m/s (B) 2.10×10^{-4} m/s (C) 1.5×10^{-4} m/s (D) 1.25×10^{-4} m/s

10. The terminal velocity of a sphere moving through a viscous medium is :
(A) directly proportional to the radius of the sphere
(B) inversely proportional to the radius of the sphere
(C) directly proportional to the square of the radius of sphere
(D) inversely proportional to the square of the radius of sphere

11. A solid sphere falls with a terminal velocity of 10 m/s in air. If it is allowed to fall in vacuum,
(A) terminal velocity will be more than 10 m/s (B) terminal velocity will be less than 10 m/s
(C) terminal velocity will be 10 m/s (D) there will be no terminal velocity

12. Spherical balls of radius R are falling in a viscous fluid of viscosity η with a velocity ν. The retarding viscous force acting on the spherical ball is : **[AIEEE 2004, 3/225, –1]**
(A) directly proportional to R but inversely proportional to ν
(B) directly proportional to both radius R and velocity ν
(C) inversely proportional to both radius R and velocity ν
(D) inversely proportional to R but directly proportional to ν

13. If 'S' is stress and 'Y' is Young's modulus of material of a wire, the energy stored in the wire per unit volume is : **[AIEEE 2005, 3/225, –1]**
(A) $2S^2Y$ (B) $\frac{S^2}{2Y}$ (C) $\frac{2Y}{S^2}$ (D) $\frac{S}{2Y}$

14. If the terminal speed of a sphere of gold (density = 19.5 kg/m^3) is 0.2 m/s in a viscous liquid then find the terminal speed of sphere of silver (density = 10.5 kg/m^3) of the same size in the same liquid (density = 1.5 kg/m^3). **[AIEEE 2006, 3/165, –1]**
(A) 0.4 m/s (B) 0.133 m/s (C) 0.1 m/s (D) 0.2 m/s

15. A wire elongates by ℓ mm when a load W is hanged from it. If the wire goes over a pulley and two weights W each are hung at the two ends, the elongation of the wire will be (in mm) **[AIEEE 2006, 3/165, –1]**
(A) ℓ (B) 2ℓ (C) zero (D) $\ell/2$

16. A spherical solid ball of volume V is made of a material of density ρ_1. It is falling through a liquid of density ρ_2 ($\rho_2 < \rho_1$). Assume that the liquid applies a viscous force on the ball that is proportional to the square of its speed v, i.e., $F_{viscous} = -kv^2$ (k > 0). The terminal speed of the ball is **[AIEEE-2008, 3/105]**
(A) $\frac{Vg\rho_1}{k}$ (B) $\sqrt{\frac{Vg\rho_1}{k}}$ (C) $\frac{Vg(\rho_1-\rho_2)}{k}$ (D) $\sqrt{\frac{Vg(\rho_1-\rho_2)}{k}}$

17. Two wires are made of the same material and have the same volume. However wire 1 has cross-sectional area A and wire 2 has cross-sectional area 3A. If the length of wire 1 increases by Δx on applying force F, how much force is needed to stretch wire 2 by the same amount? **[AIEEE-2009, 4/144]**
(A) 4F (B) 6F (C) 9F (D) F

18. If a ball of steel (density p = 7.8 g cm^{-3}) attains a terminal velocity of 10 cm s^{-1} when falling in a water (Coefficient of Viscosity η_{water}= 8.5 × 10^{-4} Pa.s) then its terminal velocity in glycerine (p = 1.2 g cm^{-3}, η= 13.2 Pa.s.) would be, nearly : **[AIEEE 2011, 11 May; 4, –1]**
(A) 6.25 × 10^{-4} cm s^{-1} (B) 6.45 × 10^{-4} cm s^{-1} (C) 1.5 ×10^{-5} cm s^{-1} (D)1.6 ×10^{-5} cm s^{-1}

19. The pressure that has to be applied to the ends of a steel wire of length 10 cm to keep its length constant when its temperature is raised by 100°C is : **[Jee- Main 2014]**
(For steel Young's modulus is 2 × 10^{11} N m^{-2} and coefficient of thermal expansion is 1.1 × 10^{-5} K^{-1})
(A) 2.2 × 10^8 Pa (B) 2.2 × 10^9 Pa (C) 2.2 × 10^7 Pa (D) 2.2 × 10^6 Pa

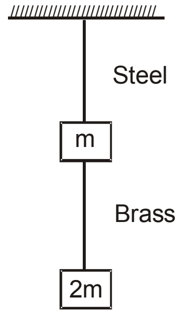
20. A pendulum made of a uniform wire of cross sectional area A has time period T. When an additional mass M is added to its bob, the time period changes to T_M. If the Young's modulus of the material of the wire is Y then $\frac{1}{Y}$ is equal to : (g = gravitational acceleration) **[JEE(Main)-2015; 4/120, –1]**
(A) $\left[\left(\frac{T_M}{T}\right)^2-1\right]\frac{A}{Mg}$ (B) $\left[\left(\frac{T_M}{T}\right)^2-1\right]\frac{Mg}{A}$ (C) $\left[1-\left(\frac{T_M}{T}\right)^2\right]\frac{A}{Mg}$ (D) $\left[1-\left(\frac{T}{T_M}\right)^2\right]\frac{A}{Mg}$

DPP No. : C28

Total Marks : 40	Max. Time : 33 min.	
Single choice Objective ('–1' negative marking) Q.1 to Q.3	(3 marks 2 min.)	[09, 06]
One or more than one options correct type ('–1' negative marking) Q.4	(4 marks 2 min.)	[04, 02]
Comprehension ('–1' negative marking) Q.5 to Q.9	(3 marks 2 min.)	[15, 10]
Subjective Questions ('–1' negative marking) Q.10 to Q.12	(4 marks 5 min.)	[12, 15]

1. A brass rod of length 2 m and cross-sectional area 2.0 cm^2 is attached end to end to a steel rod of length L and cross-sectional area 1.0 cm^2. The compound rod is subjected to equal and opposite pulls of magnitude 5 × 10^4 N at its ends. If the elongations of the two rods are equal, the length of the steel rod (L) is (Y_{Brass} = 1.0 × 10^{11} N/m^2 and Y_{Steel} = 2.0 × 10^{11} N/m^2)
(A) 1.5 m (B) 1.8 m (C) 1 m (D) 2 m

2. If the ratio of lengths, radii and Young's modulii of steel and brass wires in the figure are a, b and c respectively. Then the corresponding ratio of increase in their lengths would be :



(A) $\frac{2ac}{b^2}$ (B) $\frac{3a}{2b^2c}$

(C) $\frac{3c}{2ab^2}$ (D) $\frac{2a^2c}{b}$

3. Two thin rods of length ℓ_1 and ℓ_2 at a certain temperature are joined to each other end to end. The composite rod is then heated through a temperature θ. The coefficients of linear expansion of the two rods are α_1 and α_2 respectively. Then, the effective coefficient of linear expansion of the composite rod is:

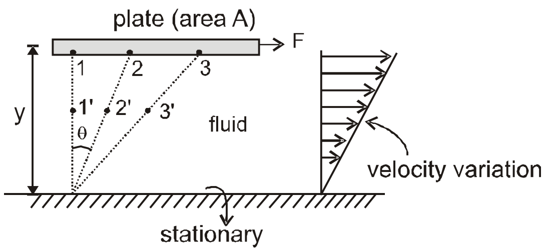
(A) $\frac{\alpha_1 + \alpha_2}{2}$ (B) $\sqrt{\alpha_1 . \alpha_2}$ (C) $\frac{l_1\alpha_2 + l_2\alpha_1}{l_1 + l_2}$ (D) $\frac{l_1\alpha_1 + l_2\alpha_2}{l_1 + l_2}$

4. A metallic wire of length ℓ is held between two supports under some tension. The wire is cooled through $\theta°$. Let Y be the Young's modulus, ρ the density and α the thermal coefficient of linear expansion of the material of the wire. Therefore, the frequency of oscillations of the wire varies as

(A) $\sqrt{Y}$ (B) $\sqrt{\theta}$ (C) $\frac{1}{\ell}$ (D) $\sqrt{\frac{\alpha}{\rho}}$

COMPREHENSION

Viscosity is the property of fluid by virtue of which fluid offers resistance to deformation under the influence of a tangential force.



In the given figure as the plate moves the fluid particle at the surface moves from position 1 to 2 and so on, but particles at the bottom boundary remains stationary. If the gap between plate and bottom boundary is small, fluid particles in between plate and bottom moves with velocities as shown by linear velocity distribution curve otherwise the velocity distribution may be parabolic. As per Newton's law of viscosity the tangential force is related to time rate of deformation -

$\frac{F}{A} \alpha \frac{d\theta}{dt}$ but $y\frac{d\theta}{dt} = u, \frac{d\theta}{dt} = \frac{u}{y}$

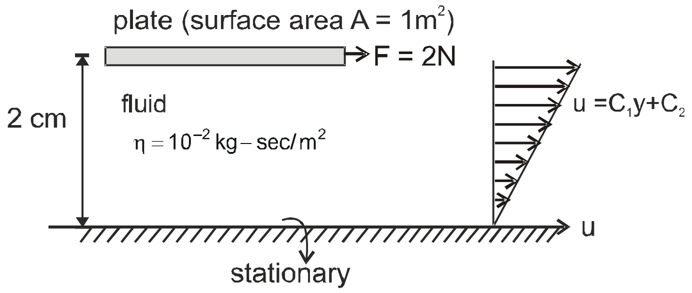
then $F = \eta A\frac{u}{y}$, η = coefficient of viscosity

for non-linear velocity distribution -

$F = \eta A\frac{du}{dy}$

where $\frac{u}{y}$ or $\frac{du}{dy}$ is known as velocity gradient.

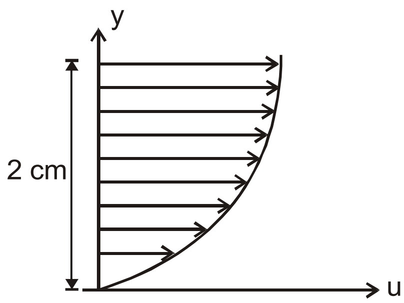
5. In the given figure if force of 2N is required to maintain constant velocity of plate, the value of constant C_1 & C_2 are -



(A) 100, 100 (B) 0 , 100 (C) 200 , 0 (D) 0 , 200

6. In previous question the value of constant speed of plate (m/sec.) is equal to -
(A) 0 (B) 4 (C) 2 (D) 1

7. If velocity distribution is given as (parabolic) :
$u = c_1y^2 + c_2y + c_3$



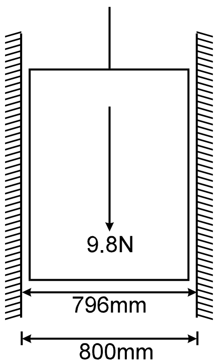
for the same force of 2N and the speed of the plate 2 m/sec, the constants C_1, C_2 & C_3 are-
(A) 200, 200 , 0 (B) 5000 , 200 , 0 (C) 5000 , 0 , 0 (D) 500, 200 , 0

8. The velocity gradient just below the plate. in above problem is equal to - (per second)
(A) Zero (B) 100 (C) 500 (D) 200

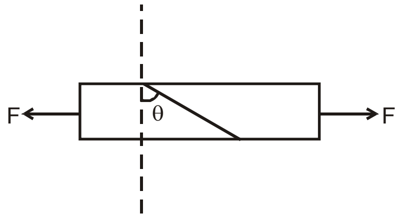
9. The velocity gradient just near the bottom boundary is equal to -
(A) Zero (B) 100 (C) 500 (D) 200

10. The cross-section of a bar is given by $\left[1+\frac{x^2}{100}\right]$ cm^2 , where ' x ' is the distance from one end. If the extension under a load of '20 k N' on a length of 10 cm is $\lambda \times 10^{-3}$ cm then find λ .
$Y = 2 \times 10^5$ N/mm^2 .

11. A piston of 796 mm diameter and 200 mm long works in a cylinder of 800 mm diameter as shown in figure. If the annular space is filled with a lubricating oil of viscosity 5 centipoises, calculate the constant speed (nearest to integer) (in m/s) of descent of piston in vertical position. The weight of piston and the axial load are 9.8 N.



12. A bar of cross-section A is subjected to equal and opposite tensile forces F at its ends. Consider a plane through the bar making an angle θ with a plane at right angles to the bar



(a) What is the tensile stress at this plane in terms of F, A and θ ?
(b) What is the shearing stress at the plane, in terms of F, A and θ ?
(c) For what value of θ is the tensile stress a maximum ?
(d) For what value of θ is the shearing stress a maximum?

DPP No. : C29 (JEE-Advanced)

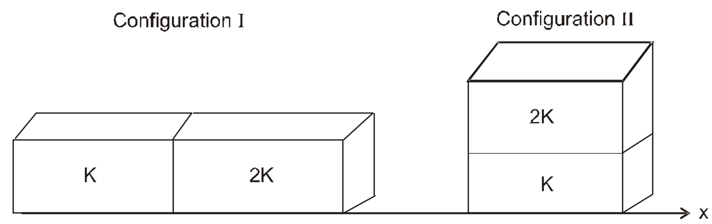
Total Marks : 43	**Max. Time : 35 min.**	
Single choice Objective ('–1' negative marking) Q.1 to Q.6	**(3 marks, 2 min.)**	**[18, 12]**
One or more than one options correct type ('–1' negative marking) Q.7	**(4 marks 2 min.)**	**[04, 02]**
Comprehension ('–1' negative marking) Q.8 to Q.10	**(3 marks 2 min.)**	**[09, 06]**
Subjective Questions ('–1' negative marking) Q.11 to Q.13	**(4 marks 5 min.)**	**[12, 15]**

1. A boiler is made of a copper plate 2.4 mm thick with an inside coating of a 0.2 mm thick layer of tin. The surface area exposed to gases at 700°C is 400 cm^2. The amount of steam that could be generated per hour at atmospheric pressure is (K_{cu} = 0.9 and K_{tin} = 0.15 cal/cm/s/°C and L_{steam} = 540 cal/g)
(A) 5000 Kg (B) 1000 kg (C) 4000 kg (D) 200 kg

2. A lake surface is exposed to an atmosphere where the temperature is < 0°C. If the thickness of the ice layer formed on the surface grows from 2 cm to 4 cm in 1 hour, The atmospheric temperature, T_a will be-
(Thermal conductivity of ice K = 4 x 10^{-3} cal/cm/s/°C; density of ice = 0.9 gm/cc. Latent heat of fusion of ice = 80 cal/gm. Neglect the change of density during the state change. Assume that the water below the ice has 0° temperature every where)
(A) – 20 °C (B) 0 °C (C) – 30 °C (D) – 15 °C

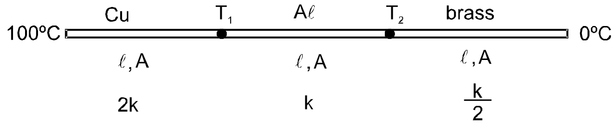
3. Two models of a windowpane are made. In one model, two identical glass panes of thickness 3 mm are separated with an air gap of 3 mm. This composite system is fixed in the window of a room. The other model consists of a single glass pane of thickness 6 mm, the temperature difference being the same as for the first model. The ratio of the heat flow for the double pane to that for the single pane is
(K_{glass} = 2.5 × 10^{-4} cal/s.m. °C and K_{air} = 6.2 × 10^{-6} cal/s.m.°C)
(A) 1/20 (B) 1/70 (C) 31/1312 (D) 31/656

4. Two rectangular blocks, having indentical dimensions, can be arranged either in configuration I or in configuration II as shown in the figure, On of the blocks has thermal conductivity k and the other 2k. The temperature difference between the ends along the x-axis is the same in both the configurations. It takes 9s to transport a certain amount of heat from the hot end to the cold end in the configuration I. The time to transport the same amount of heat in the configuration II is :
[JEE(Advanced)-2013,3/60,–1]



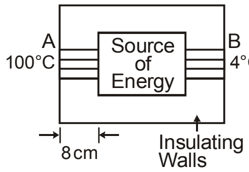
(A) 2.0 s (B) 3.0 s (C) 4.5 s (D) 6.0 s

5. Three metal rods made of copper, aluminium and brass, each 20 cm long and 4 cm in diameter, are placed end to end with aluminium between the other two. The free ends of copper and brass are maintained at 100 and 0°C respectively. Assume that the thermal conductivity of copper is twice that of aluminium and four times that of brass. The approximately equilibrium temperatures of the copper-aluminium and aluminium-brass junctions are respectively.



(A) 68 °C and 75 °C (B) 75 °C and 68 °C (C) 57 °C and 86 °C (D) 86 °C and 57 °C

6. A closed cubical box is made of a perfectly insulating material walls of thickness 8 cm and the only way for heat to enter or leave the box is through two solid metallic cylindrical plugs, each of cross-sectional area 12 cm^2 and length 8 cm, fixed in the opposite walls of the box. The outer surface A on one plug is maintained at 100°C while the outer surface B of the other plug is maintained at 4°C. The thermal conductivity of the material of each plug is 0.5 cal/°C/cm. A source of energy generating 36 cal/s is enclosed inside the box. Assuming the temperature to be the same at all points on the inner surface, the equilibrium temperature of the inner surface of the box is

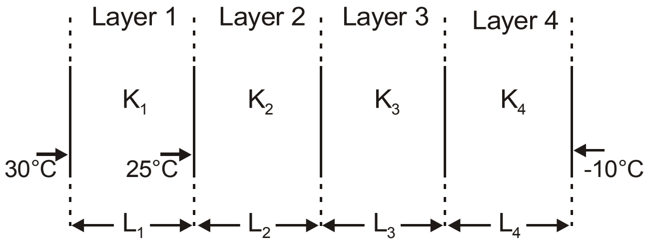


(A) 62 °C (B) 46 °C (C) 76 °C (D) 52 °C

7. Two identical rods made of two different metals A and B with thermal conductivities K_A and K_B respectively are joined end to end. The free end of A is kept at a temperature T_1 while the free end of B is kept at a temperature T_2 ($< T_1$). Therefore, in the steady state **[Olympiad (Stage-1) 2017]**
(A) the temperature of the junction will be determined only by K_A and K_B
(B) if the lengths of the rods are doubled the rate of heat flow will be halved.
(C) if the temperature at the two free ends are interchanged the junction temperature will change
(D) the composite rod has an equivalent thermal conductivity of $\frac{2K_AK_B}{K_A + K_B}$

COMPREHENSION

Figure shows in cross section a wall consisting of four layers with thermal conductivities K_1=0.06 W/mK; K_3 = 0.04 W/mK and K_4 = 0.10 W/mK. The layer thicknesses are L_1 = 1.5 cm ; L_3 = 2.8 cm and L_4=3.5 cm. The temperature of interfaces is as shown in figure. Energy transfer through the wall is steady.



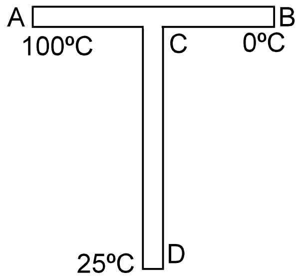
8. The temperature of the interface between layers 3 and 4 is :
(A) – 1°C (B) – 3°C (C) 2°C (D) 0°C

9. The temperature of the interface between layers 2 and 3 is :
(A) 11°C (B) 8°C (C) 7.2°C (D) 5.4°C

10. If layer thickness L_2 is 1.4 cm, then its thermal conductivity K_2 will have value (in W/mK) :
(A) 2×10^{-2} (B) 2×10^{-3} (C) 4×10^{-2} (D) 4×10^{-3}

11. One end of a steel rod (K = 42 J/m–s–ºC) of length 1.0 m is kept in ice at 0ºC and the other end is kept in boiling water at 100ºC. The area of cross–section of the rod is 0.04cm^2. Assuming no heat loss to the atmosphere, find the mass of the ice melting per second. Latent heat of fusion of ice = 3.36 × 10^5 J/kg.

12. A rod CD of thermal resistance 5.0 K/W is joined at the middle of an identical rod AB as shown in figure. The ends A, B and D are maintained at 100ºC, 0ºC and 25ºC respectively. Find the heat current in CD.



13. A metal rod of cross-sectional area 1.0 cm^2 is being heated at one end. At one time, the temperature gradient is 5.0°C/cm at cross-section A and is 2.6 °C/cm at cross-section B. Calculate the rate at which the temperature is increasing in the part AB of the rod. The heat capacity of the part AB = 0.40 J/°C, thermal conductivity of the material of the rod = 200 W/m–°C. Neglect any loss of heat to the atmosphere.

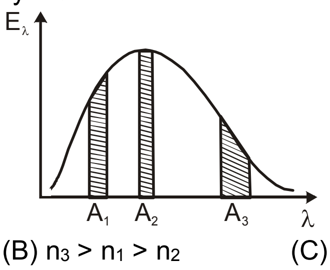
DPP No. : C30 (JEE-Advanced)

Total Marks : 53		Max. Time : 47 min.
Single choice Objective ('–1' negative marking) Q.1 to Q.7	(3 marks, 2 min.)	[21, 14]
One or more than one options correct type ('–1' negative marking) Q.8	(4 marks 2 min.)	[04, 02]
Subjective Questions ('–1' negative marking) Q.9 to Q.13	(4 marks 5 min.)	[20, 25]
Match the Following (no negative marking) Q.14	(8 marks, 6 min.)	[08, 06]

1. Heat flows radially outward through a spherical shell of outside radius R_2 and inner radius R_1. The temperature of inner surface of shell is θ_1 and that of outer is θ_2. The radial distance from centre of shell where the temperature is just half way between θ_1 and θ_2 is :

(A) $\frac{R_1+R_2}{2}$ (B) $\frac{R_1 R_2}{R_1+R_2}$ (C) $\frac{2 R_1 R_2}{R_1+R_2}$ (D) $R_1 + \frac{R_2}{2}$

2. Three separate segments of equal area A_1, A_2 and A_3 are shown in the energy distribution curve of a blackbody radiation. If n_1, n_2 and n_3 are number of photons emitted per unit time corresponding to each area segment respectively then :

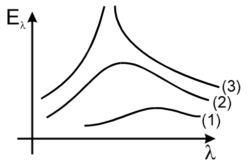


(A) $n_2 > n_1 > n_3$ (B) $n_3 > n_1 > n_2$ (C) $n_1 = n_2 = n_3$ (D) $n_3 > n_2 > n_1$

3. The earth is getting energy from the sun whose surface temperature is T_s and radius is R. Let the radius of the earth the r and the distance from the sun be d. Assume the earth and the sun both to behave as perfect black bodies and the earth is in thermal equilibrium at a constant temperature T_e. Therefore, the temperature T_s of the sun is xT_e where x is

(A) $\sqrt{\frac{2d}{R}}$ (B) $\sqrt{\frac{2R}{r}}$ (C) $\sqrt{\frac{4d}{r}}$ (D) $\frac{d}{r}$

4. Three graphs marked as 1, 2, 3 representing the variation of maximum emissive power and wavelength of radiation of the sun, a welding arc and a tungsten filament. Which of the following combination is correct

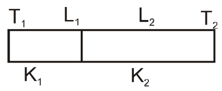


(A) 1- bulb, 2 $\rightarrow$ welding arc, 3 $\rightarrow$ sun
(B) 2- bulb, 3 $\rightarrow$ welding arc, 1 $\rightarrow$ sun
(C) 3- bulb, 1 $\rightarrow$ welding arc, 2 $\rightarrow$ sun
(D) 2- bulb, 1 $\rightarrow$ welding arc, 3 $\rightarrow$ sun

5. Assuming the sun to be a spherical body of radius R at a temperature of T K, evaluate the total radiant power, incident on Earth, at a distance r from the Sun. (earth radius = r_0) **(AIEEE-2006; 3/180)**

(A) $\frac{R^2\sigma T^4}{r^2}$ (B) $\frac{4\pi r_0^2 \quad R^2\sigma T^4}{r^2}$ (C) $\frac{\pi r_0^2 \quad R^2\sigma T^4}{r^2}$ (D) $\frac{r_0^2 \quad R^2\sigma T^4}{4\pi r^2}$

6. One end of a thermally insulated rod is kept at a temperature T_1 and the other at T_2. The rod is composed of two sections of lengths L_1 and L_2 and thermal conductivities k_1 and k_2 respectively. The temperature at the interface of the sections is



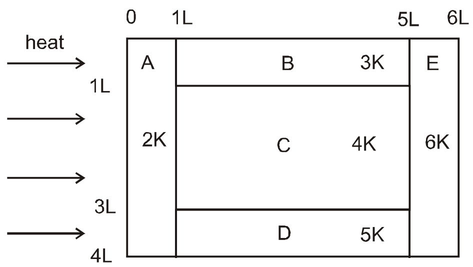
(AIEEE-2007; 3/120)

(A) $\frac{(K_2 \quad L_2 \quad T_1 + K_1 \quad L_1T_2)}{(K_1L_1 + K_2L_2)}$
(B) $\frac{(K_2 \quad L_1 \quad T_1 + K_1 \quad L_2T_2)}{(K_2L_1 + K_1L_2)}$
(C) $\frac{(K_1 \quad L_2 \quad T_1 + K_2 \quad L_1T_2)}{(K_1L_2 + K_2L_1)}$
(D) $\frac{(K_1 \quad L_1 \quad T_1 + K_2 \quad L_2T_2)}{(K_1L_1 + K_2L_2)}$

7. Three rods of Copper, brass and steel are welded together to form a Y-shaped structure. Area of cross-section of each rod = 4 cm^2. End of copper rod is maintained at 100°C where as ends of brass and steel are kept at 0°C. Lengths of the copper, brass and steel rods are 46, 13 and 12 cms respectively. The rods are thermally insulated from surroundings except at ends. Thermal conductivities of copper, brass and steel are 0.92, 0.26 and 0.12 CGS units respectively. Rate of heat flow through copper rod is: **[JEE (Main) 2014, 4/120, –1]**

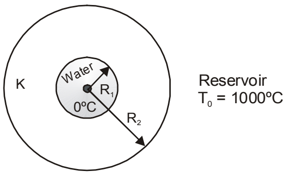
(A) 1.2 cal/s (B) 2.4 cal/s (C) 4.8 cal/s (D) 6.0 cal/s

8. A composite block is made of slabs A, B, C, D and E of different thermal conductivities (given in terms of a constant K) and sizes (given in terms of length, L) as shown in the figure. All slabs are of same width. Heat 'Q' flows only from left to right through the blocks. Then in steady state
[JEE, 2011, 4,/160]



(A) heat flow through A and E slabs are same
(B) heat flow through slab E is maximum
(C) temperature difference across slab E is smallest
(D) heat flow through C = heat flow through B + heat flow through D.

9. A hollow spherical conducting shell of inner radius $R_1 = 0.25$ m and outer radius $R_2 = 0.50$ m is placed inside a heat reservoir of temperature $T_0 = 1000$ ºC. The shell is initially filled with water at 0ºC. The thermal conductivity of the material is $k = \frac{10^2}{4\pi}$ W/m-K and its heat capacity is negligible. The time required to raise the temperature of water to 100ºC is $1100\,K\,\ell n\,\frac{10}{9}$ sec. Find K. Take specific heat of water s = 4.2 kJ/kg.°C, density of water $d_w = 1000$ kg/m^3, $\pi = \frac{22}{7}$



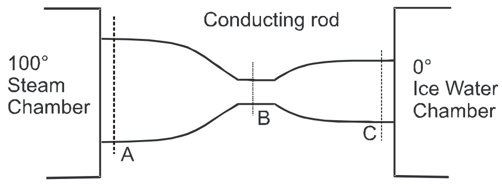
10. A metal rod AB of length 10 *x* has its one end A in ice at 0ºC and the other end B in water at 100ºC. If a point P on the rod is maintained at 400ºC, then it is found that equal amounts of water and ice evaporate and melt per unit time. The latent heat of evaporation of water is 540 cal/g and latent heat of melting of ice is 80 cal/g. If the point P is at a distance of λx from the ice end A, find the value of λ. [Neglect any heat loss to the surrounding] **[JEE, 2009, 4,/160, –1]**

11. A hollow metallic sphere of radius 20 cm surrounds a concentric metallic sphere of radius 5 cm. The space between the two spheres is filled with a nonmetallic material. The inner and outer spheres are maintained at 50°C and 10°C respectively and it is found that 160 π Joule of heat passes radially from the inner sphere to the outer sphere per second. Find the thermal conductivity of the material between the spheres.

12. A blackbody of surface area 1 cm^2 is placed inside an enclosure. The enclosure has a constant temperature 27ºC and the blackbody is maintained at 327ºC by heating it electrically. What electric power is needed to maintain the temperature? $\sigma = 6.0 \times 10^{-8}$ W/m^2 –K^4.

13. Estimate the temperature at which a body may appear blue or red. The values of λ_{mean} for these are 5000 Å and 7500Å respectively. [Given Wein's constant b = 0.3 cm K]

14. A copper rod (initially at room temperature 20°C) of non-uniform cross section is placed between a steam chamber at 100°C and ice-water chamber at 0°C.



(A) Initially rate of heat flow $\left(\frac{dQ}{dt}\right)$ will be — (p) maximum at section A

(B) At steady state rate of heat flow $\left(\frac{dQ}{dt}\right)$ will be — (q) maximum at section B

(C) At steady state temperature gradient $\left|\left(\frac{dT}{dx}\right)\right|$ will be — (r) minimum at section A

(D) At steady state rate of change of temperature $\left(\frac{dT}{dt}\right)$ at a certain point will be — (s) minimum at section B

(t) same for all section

DPP No. : C31 (JEE-Advanced)

Total Marks : 37		Max. Time : 31 min.
Single choice Objective ('–1' negative marking) Q.1 to Q.4	(3 marks, 2 min.)	[12, 08]
One or more than one options correct type ('–1' negative marking) Q.5	(4 marks 2 min.)	[04, 02]
Comprehension ('–1' negative marking) Q.6 to Q.8	(3 marks 2 min.)	[09, 06]
Subjective Questions ('–1' negative marking) Q.9 to Q.11	(4 marks 5 min.)	[12, 15]

1. Three very large plates of same area are kept parallel and close to each other. They are considered as ideal black surfaces and have very high thermal conductivity. The first and third plates are maintained at temperatures 2T and 3T respectively. The temperature of the middle (i.e. second) plate under steady state condition is **[IIT-JEE-2012, Paper-1; 3/70, –1]**

(A) $\left(\frac{65}{2}\right)^{\frac{1}{4}}T$ (B) $\left(\frac{97}{4}\right)^{\frac{1}{4}}T$ (C) $\left(\frac{97}{2}\right)^{\frac{1}{4}}T$ (D) $(97)^{\frac{1}{4}}T$

2. Parallel rays of light of intensity $I = 912\ Wm^{-2}$ are incident on a spherical balck body kept in surroundings of temperature 300 K. Take Stefan-Biltzmann constant $\sigma = 5.7 \times 10^{-8}\ Wm^{-2}K^{-4}$ and assume that the energy exchange with the surroundings is only through radiation. Th final steady state temperature of the black body is close to: **[JEE (Advanced)-2014, 3/60, –1]**

(A) 330 K (B) 660 K (C) 990 K (D) 1550 K

3. A human body has surface area of approximately $1m^2$. The normal body temperature is 10 K above the surrounding room temperature T_0. Take the room temperature to be T_0 = 300 K. For T_0 = 300K, the value of $\sigma T_0^4 = 460\ Wm^{-2}$ (where σ is the Stefan-Boltzmann constant). Which of the following options is/are correct ? **[JEE (Advanced) 2017 ; P-1, 4/61, –2]**

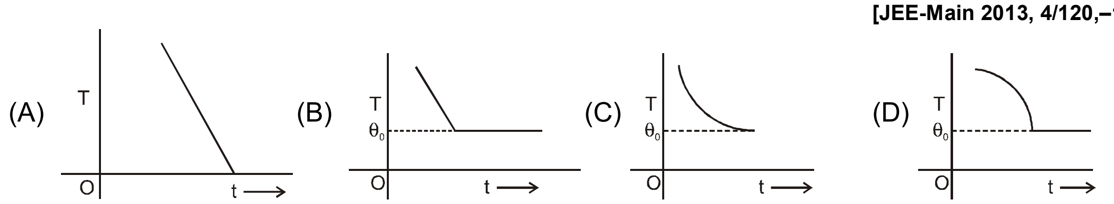
(A) If the surrounding temperature reduces by a small amount $\Delta T_0 << T_0$, then to maintain the same body temperature the same (living) human being needs to radiate $\Delta W = 4\sigma T_0^3 \Delta T_0$ more energy per unit time.

(B) Reducing the exposed surface area of the body (e.g. by curling up) allows humans to maintain the same body temperature while reducing the energy lost by radiation

(C) If the body temperature rises significantly then the peak in the spectrum of electromagnetic radiation emitted by the body would shift to longer wavelengths

(D) The amount of energy radiated by the body in 1 second is close to 60 joules

4. If a piece of metal is heated to temperature θ and then allowed to cool ina room which is at temperature θ_0, the graph between the temperature T of the metal and time t will be closest to : **[JEE-Main 2013, 4/120,–1]**



5. An incandescent bulb has a thin filament of tungsten that is heated to high temperature by passing an electric current. The hot filament emits black-body radiation. The filament is observed to break up at random locations after a sufficiently long time of operation due to non-uniform evaporation of tungsten from the filament. If the bulb is powered at constant voltage, which of the following statement(s) is (are)true? **[JEE Advanced 2016 ; P-1, 4/62, –2]**

(A) The temperature distribution over the filament is uniform

(B) The resistance over small sections of the filament decreases with time

(C) The filament emits more light at higher band of frequencies before it breaks up

(D) The filament consumes less electrical power towards the end of the life of the bulb

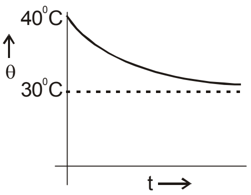
COMPREHENSION # 2✍

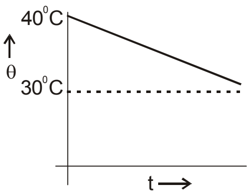
A body cools in a surrounding of constant temperature 30ºC. Its heat capacity is 2J/ºC. Initial temperature of the body is 40ºC . Assume Newton's law of cooling is valid. The body cools to 38ºC in 10 minutes.

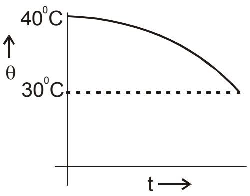
6.✍ In further 10 minutes it will cool from 38ºC to :

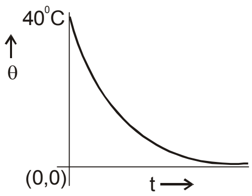
(A) 36ºC (B) 36.4ºC (C) 37ºC (D) 37.5ºC

7.✍ The temperature of the body in ºC denoted by θ the variation of θ versus time t is best denoted as

(A)


(B)


(C)


(D)


8.✍ When the body temperature has reached 38 ºC, it is heated again so that it reaches to 40ºC in 10 minutes. The total heat required from a heater by the body is:

(A) 3.6J (B) 7J (C) 8 J (D) 4 J

9. A liquid cools from 70ºC to 60ºC in 5 minutes. Find the time in which it will further cool down to 50 ºC, if its surrounding is held at a constant temperature of 30ºC.

10.✍ Two spherical bodies A (radius 6 cm) and B (radius 18 cm) are at temperature T_1 and T_2 respectively. The maximum intensity in the emission spectrum of A is at 500 nm and in that of B is at 1500 nm. Considering them to be black bodies, what will be the ratio of the rate of total energy radiated by A to that of B ? **[JEE, 2010, 3,/163]**

11. A metal is heated in a furnace where a sensor is kept above the metal surface to read the power radiated (P) by the metal. the sensor has scale that displays $\log_2 (P / P_0)$, where P_0 is a constant. When the metal surface is at a temperature of 487 ºC, the sensor shows a value 1. Assume that the emissivity of the metallic surface remains constant. What is the value displayed by the sensor when the temperature of the metal surface is raised to 2767 ºC. **[JEE Advanced 2016 ; P-1, 3/62]**

ANSWERS

DPP No. : C1

7. $\tau = \frac{\lambda^2 R}{\pi \epsilon_0} \ell n\left(\frac{R+r}{r}\right)$

8. 6 mg $\cos^2 (\theta/2)$ **9.** 3

DPP No. : C2

7. 4 **8.** 7 **9.** 40

DPP No. : C3

8. 5 **9.** $\frac{72v}{55\ell}, \frac{\pi\ell}{3}, \frac{24mv}{55}$

DPP No. : C6

9. $F = \frac{mg}{\sqrt{1-\left(\frac{m}{m+M}\right)^2}}$

DPP No. : C7

7. $\cos^{-1}\left(\frac{2}{3}\right)$ **8.** $\frac{13P^2}{10M}$ **9.** 4

DPP No. : C8

6. 1 V **7.** $Q = \frac{1}{2}C\varepsilon_2^2$. It is remarkable that the result obtained is independent of ε_1.

8. 07 **9.** 90

DPP No. : C10

8. $i = \frac{\varepsilon}{2R}\left(1-e^{-\frac{2t}{3RC}}\right)$ **9.** $E=\frac{(\pi+3)}{24}\frac{\mu\omega^2 A^2}{K}$

DPP No. : C11

9. 5

DPP No. : C13

11. $B = 2.1 \times 10^{-8}$ kT **12.** (a) 23.9 GHz

(b) $60 \sin (0.5 \times 10^3 x + 1.5 \times 10^{11} t)$ V/m

DPP No. : C14

1. 1.2×10^{-6} N

2. $E_{rms} = 2.9$ V/m, $B_{rms} = 9.6 \times 10^{-9}$ T

8. $B = 0.74 \times 10^{-3}$ T

DPP No. : C17

8. 9 **9.** 0

DPP No. : C18

7. $u = \sqrt{\frac{48}{5}g\ell}$

8. (a) $T = 40 (3 \cos \theta - 2 \cos \theta_0)$ kg f.

(b) $\theta_0 = 60°$ **9.** 19

DPP No. : C22

10. x = 2

DPP No. : C24

4. 3.98×10^{-2} J **5.** 1.44×10^{-5} J

6. $24\pi R^2 S$ **7.** (a) 465 N/m^2

(b) 30 N/m^2 (c) 38 N/m^2 **8.** 8

9. 6

DPP No. : C25

11. $T = \frac{p_0(2r^3 - R^3)}{4(R^2 - 2r^2)}$ **12.** 100N/m^2

13. 4 **14.** 4

DPP No. : C26

11. 4 **12.** $\frac{4}{3}\times 10^{-4}, \frac{8}{3}\times 10^{-4}$

13. 3

DPP No. : C28

10. 8 **11.** 8

12. (a) $\frac{F\cos^2\theta}{A}$ (b) $\frac{F\sin 2\theta}{2A}$

(c) $\theta = 0°$ (d) $\theta = 45°$

DPP No. : C29

11. 5×10^{-5} g/s **12.** 4.0 W

13. 12 °C/s

DPP No. : C30

9. 5 **10.** 9 **11.** 15 W/m–°C

12. 0.73 W. **13.** 6×10^3 K; 4×10^3 K

DPP No. : C31

9. 7 minutes **10.** 9 **11.** 9