PHYSICS QUESTIONS FOR ADVANCE TEST PAPER 2017

Properties of Matter

1. Volumes V_1 and V_2 of a liquid are maintained in two calorimeters at temperatures θ_1 and θ_2 ($\theta_2 > \theta_1$). Coefficient of volume expansion of the liquid is independent of temperature. Now liquids from both the calorimeter are poured into another calorimeter of negligible heat capacity. Heat loss to the surroundings is strictly restricted. Final volume V of the mixture after they are well mixed is best represented by the equation

(a) $V = V_1 + V_2$ (b) $V > V_1 + V_2$
(c) $V < V_1 + V_2$ (d) Insufficient information

2. Radii of a slightly tapered cylindrical wire of length L at its ends are a and b. It is stretched by two forces each of magnitude F applied at its ends. The forces are uniformly distributed over the end faces. If Young's modulus of material of the wire is denoted by Y, extension produced is

(a) $\frac{4FL}{\pi(a+b)^2 Y}$ (b) $\frac{FL}{\pi(a^2+b^2)Y}$
(c) $\frac{FL}{\pi(a^2-b^2)Y}$ (d) $\frac{FL}{\pi abY}$

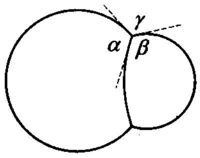
3. A long capillary tube of radius r is put in contact with surface of a perfectly wetting liquid of density ρ and very low viscosity. What maximum height h the liquid can rise inside the capillary? Here height is measured above the level of the liquid outside the capillary. Surface tension of the liquid and acceleration due to gravity are denoted by σ and g respectively.

(a) $h = \frac{2\sigma}{\rho gr}$ (b) $h = \frac{4\sigma}{\rho gr}$
(c) $\frac{2\sigma}{\rho gr} < h < \frac{4\sigma}{\rho gr}$
(d) Insufficient information

4. Consider two hollow glass spheres; one of them containing water in approximately 10% of its volume, and the other containing a similar volume of mercury. If the spheres are brought in a zero gravity environment of a space-shuttle, what will you observe?

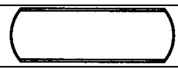
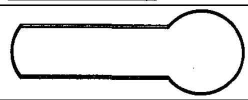
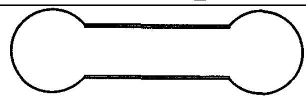
(a) Water and mercury both float in their spheres as spherical drops.
(b) Water forms a layer on inner surface of the sphere while mercury floats as a spherical drop.
(c) Mercury forms a layer on inner surface of the sphere while water floats as a spherical drop.
(d) In each case, some amounts of the liquids form layers on inner surfaces of the spheres and remaining amounts float as spherical drops.

5. When two soap bubbles of different radii coalesce, some portions of their surfaces make a common surface. At any point on the circumference of the common surface, the three surfaces meet at angles α, β and γ. What relation should these angles bear?



(a) α > β (b) α > β > γ
(c) α = β < y (d) α = β = γ

6. Air is confined in a thin-walled glass tube with the help of soap films at the ends of the tube. These films on both the ends have equal radii of curvatures. By some arrangement not shown here, these soap films are given different shapes. In the first and the second columns of the following table, different shapes of the soap films and possible nature of equilibrium of the system are shown respectively. Suggest suitable matches.
You may need the expression $V = 1/3\pi h^2(3R–h)$. Here Vis volume of a spherical cap of height h cut from a sphere of radius R.

	Shape of the soap films		**Nature of equilibria**
(a)		(p)	Stable
(b)		(q)	Unstable
(c)		(s)	Neutral
(d)		(r)	Not in equilibrium

(a) a → p, b → p, c → p, d → q
(b) a → q, b → p, c → p, d → s
(c) a → s, b → p, c → r, d → q
(d) a → p, b → q, c → r, d → s

Oscillations and Waves

7. A particle of mass m can move in a force field. Potential energy U varies on location of the particle according to the following equation.

$$U = –k(x – a)^2(x – b)^2$$

Here k, a and b are positive constants.
What can you conclude about small amplitude oscillations of the particle?
(a) It can oscillate about a single location with angular frequency $(b-a)\sqrt{2k/m}$.

(b) It can oscillate about two different locations with angular frequency $(b-a)\sqrt{k/m}$.

(c) It can oscillate about a single location with angular frequency $(b-a)\sqrt{k/m}$.

(d) It can oscillate about two different locations with angular frequency $(b-a)\sqrt{2k/m}$.

8. In figure-I, is shown acoustic pressure variation with position in a harmonic sound wave travelling in the positive *x*-direction. Period of the sound wave is 8 s. Figure-I was recorded at t = 10 s. In figure-II are shown variation in acoustic pressure by two curves recorded at two successive instants of time $t = t_1$ and then $t = t_2$. Both the figures are drawn to the same scale.
Which of the following sets correctly express possible values of the instants t_1 and t_2?

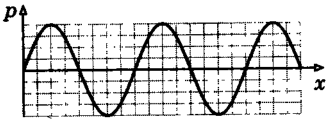


Figure-I

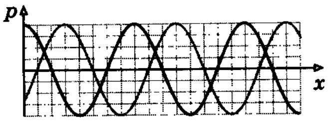
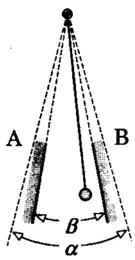


Figure-II

(a) t_1= 0 s and t_2 = 3s (b)t_1 = 11s and t_2 = 16s
(c) t_1= 8 s and t_2 = 11s (d)t_1 = 16s and t_2 = 19s

9. A simple pendulum initially oscillating simple harmonically with angular amplitude α and period T_0 is symmetrically confined between two rigid fixed planes A and B making angle β < α with each other as shown in the figure.



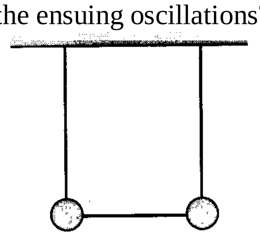
(a) If collisions at both the walls are elastic, period is $T_0(1 - \beta/\alpha)$.

(b) If collisions at both the walls are inelastic, period is T_0.

(c) If collision at one wall is elastic and at the other is inelastic, the period is T_0.

(d)If collision at one wall is elastic and at the other is inelastic, the period is less then T_0.

10. Two identical simple pendulums each of length 1 are suspended from the ceiling. Their bobs each of mass m are connected by a very light relaxed elastic cord of force constant k as shown in the figure. If the bobs are symmetrically pulled apart slightly and released, what is period of the ensuing oscillations?

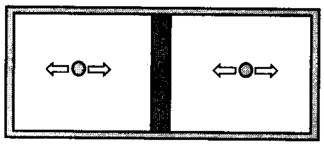


(a) $\pi\left(\frac{2k}{m}+\frac{g}{l}\right)^{-\frac{1}{2}}$ (b) $\pi\left\{\left(\frac{2k}{m}\right)^{-\frac{1}{2}}+\left(\frac{g}{l}\right)^{-\frac{1}{2}}\right\}$

(c) $\pi\left\{\left(\frac{k}{m}+\frac{g}{l}\right)^{-\frac{1}{2}}+\left(\frac{g}{l}\right)^{-\frac{1}{2}}\right\}$

(d) $\pi\left\{\left(\frac{2k}{m}+\frac{g}{l}\right)^{-\frac{1}{2}}+\left(\frac{g}{l}\right)^{-\frac{1}{2}}\right\}$

11. Consider a fixed highly evacuated cylinder in a gravity free region. Inside the cylinder, a piston of mass M can move without friction. In each part of the cylinder, a ball of mass m (m << M) is moving back and forth with very high frequency and in doing so they are colliding elastically with the ends of the cylinder and with the piston. When the piston is at the centre, it is in equilibrium as shown in the figure. Now the piston is shifted slightly towards one of the ends of cylinder with a negligible speed and then released. What will happen to the piston?



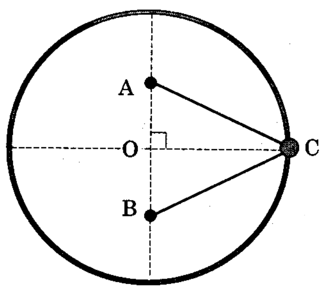
(a) It will stay where it is released.

(b) It will ultimately come at the centre and stop.

(c) It will start oscillating back and forth simple harmonically.

(d) It will start oscillating back and forth but not simple harmonically.

12. A small bead of mass m can slide on a frictionless fixed ring of radius r. With the help of two identical strings of force constant k, the bead is connected to two nails A and B each on a diameter at a distance 0.5r from centre O of the ring. Relaxed length of each string is negligible as compared to the radius of the ring. The bead is given a small velocity at point C. What can you predict about subsequent motion of the bead before any of the string strikes a nail?



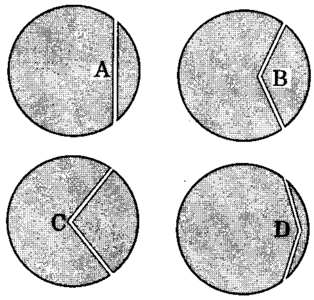
(a) It will keep moving with its initial speed.

(b) It will oscillate simple harmonically about the point C.

(c) Its angular momentum about centre O of the ring is conserved.

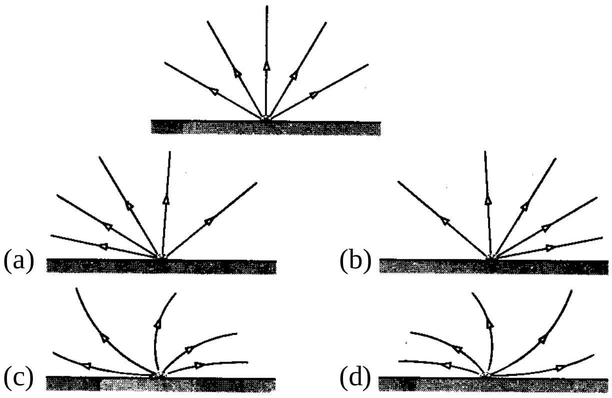
(d) Total elastic potential energy stored in both the strings is $1.25kr^2$.

13. Four tunnels are supposed to be bored through the earth between two places on a longitude as shown in the figure. One of them with midpoint at A is straight, whereas other three have bent at their midpoints B, C and D. Both the bent sections are coplanar. A particle released from one end of the tunnels, spends time intervals T_A, T_B, T_C and T_D respectively to reach the other end. If the particle passes the bent smoothly without a change in speed there, which of the following relations will these time intervals bear?



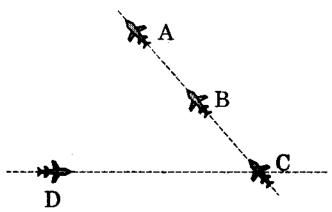
(a) $T_A = T_B = T_C = T_D$ (b) $T_A = T_C > T_B = T_D$
(c) $T_A = T_C < T_B = T_D$ (d) $T_B < T_A = T_C < T_D$

14. On a windless day, rays of the sound waves emanating from an isotropic point source placed close to the ground are shown in the figure. If a horizontal wind starts blowing towards the left with a constant and uniform velocity, which of the following will best represent pattern of the sound rays?



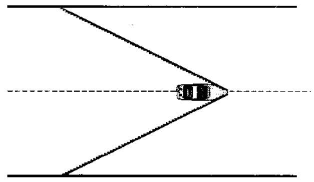
15. A detector receding from a stationary sound source with a speed that increases continuously without a limit. Which of the following statements correctly describes frequency of the sound detected by the detector? Assume that sound waves propagate indefinitely without attenuation and the detector does not create any air drag.
(a) It first decreases, becomes zero and then increases.
(b) It continuously decreases and eventually no sound is detected.
(c) It continuously decreases and eventually acquires a small value.
(d) It first decreases, becomes zero and then increases and eventually no sound is detected.

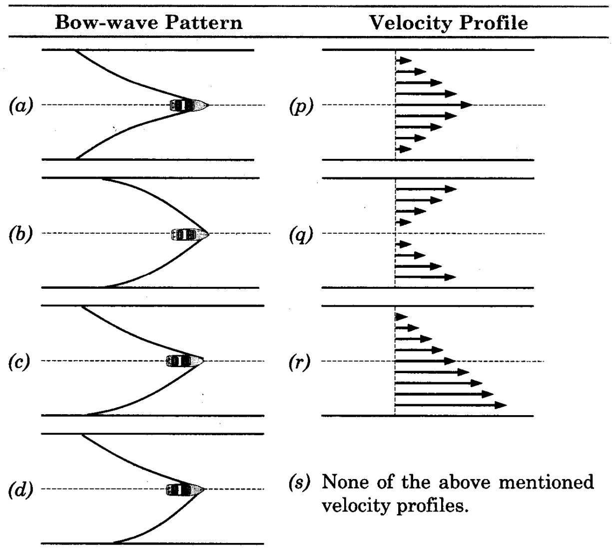
16. Three aircrafts A, B and C are flying in a line with the same speed. Another aircraft D is flying on another straight line making an acute angle with the line of motion of the aircrafts A, B and C as shown. If pilots of these aircrafts hear sound of the aircraft D simultaneously, what can you conclude about speed of the aircraft D?



(a) It is possible only when the aircraft D is moving at speed of sound.
(b) It is possible only when the aircraft D is moving at speed lower than speed of sound.
(c) It is possible only when the aircraft D is moving at speed higher than speed of sound.
(d) The pilots of aircrafts A, B and C cannot hear sound of the aircraft D simultaneously.

17. When a boat moves on stagnant water with a speed that is greater than speed of surface waves on water, the surface waves generated due to movement of the boat combine to make a V shape pattern as shown in the figure. This pattern is known as bow-waves. Various bow wave patterns and velocity profile of water flow are shown in the first and the second columns of the following table. Suggest suitable matches.





(a) a → p, b → s, c → r, d → q
(b) a → q, b → p, c → s, d → r
(c) a → s, b → p, c → r, d → q
(d) a → p, b → q, c → r, d → s

Ray and Wave Optics

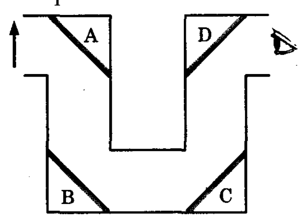
18. When the Sun is behind dark clouds and there are gaps in the clouds, you will often see sunlight "fanning" out from the gaps as shown in the given photograph.
Though the rays are closely parallel but we see them diverging as they approach the earth. Which of the following statements most suitably explains this effect?

(a) Distant objects appear smaller than nearer objects.
(b) Sunrays are actually radiated from the sun radially.
(c) Light bends at sharp corners of opaque object that it encounters.

(d) The gaps work as light sources at finite distance hence radiate diverging light.

19. Bodies that can be impregnated with water, colours of their surface appear richer after moistening. Which of the following is the most appropriate reason for this effect?
(a) Due to moistening, surface irregularities are covered with water film which reduces diffused reflection of light.
(b) Due to moistening, surface irregularities are covered with water film which reduces amount of reflected light.
(c) Due to moistening, surface irregularities are covered with water film which increases amount of reflected light.

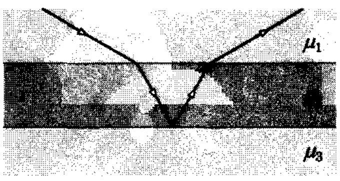
20. An arrow object is viewed through a bent metal tube with the help of four plane mirrors A, B, C and D as shown in the figure. Every mirror is inclined at an angle of 45° with the horizontal. Which of the following represents correct images made by these mirrors in sequence?



(a) ↑ ← → ↑ (b) ← ↑ → ↑
(c) → ↓ ← ↑ (d) ↑ ↓ ↑ ↓

21. While fishing from a dock, you see a fish in the water. For this, you can use either a bow and arrow, or a laser gun. Which of the following strategy you must follow?
(a)Aim the arrow as well as the laser gun both at the fish.
(b) Aim the arrow below the fish and the laser gun at the fish.
(c) Aim the arrow below the fish and the laser gun above the fish.
(d)Aim the arrow above the fish and the laser gun below the fish.

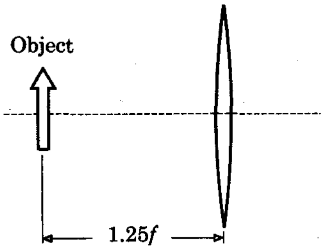
22. Light travelling through three transparent substances follows a path shown in the figure. Arrange their indices of refraction in order from smallest to largest.



(a) $\mu_3 < \mu_1 < \mu_2$ (b) $\mu_1 < \mu_3 < \mu_2$
(c) Neither of the above is possible.
(d) More information is required.

23. A lens held above a coin placed on a table forms an image of the coin. After the lens is moved vertically a distance equal to its focal length, it forms another image of the coin equal in size to the previous image. If diameter of the coin is 2.0 cm, what is the diameter of the image?
(a) 3.0 cm. (b) 4.0 cm
(c) 5.0 cm (d) 6.0 cm

24. A converging lens of focal length f is used to cast an image of an object as shown in the figure. The upper half of the lens is now covered by an opaque coating. Which of the following statements is most appropriate?



(a) Upper half of the image is brighter than its lower half.
(b) Lower half of the image is brighter than its upper half.
(c) Entire portion of the image appears with uniformly reduced brightness.
(d) Entire portion of the image appears with reduced brightness but to predict intensity distribution more information is required.

25. It is a common belief that reading in reasonably bright light is more comfortable than reading in dim light. Which of the following is the most appropriate reason for this effect?
(a) Contraction of ciliary muscles reduces astigmatism.
(b) Contraction of pupil in bright light reduces spherical aberration.
(c) In bright light image formed on retina has more intensity than that in dim light.
(d)This is purely a psychological effect; bright light merely stimulates some more visual neurons that are normally dormant.

26. Refractive indices of two varieties of glass A and B depend on wavelength 2 of light according to the following equations.

$$\mu_A = \mu_{A0} - \beta_A(\lambda - \lambda_0) \text{ and } \mu_B = \mu_{B0} - \beta_B(\lambda - \lambda_0)$$

Here λ_0 is wavelength of yellow light. An achromatic combination of lenses is made from these materials. Radii of curvature of two outer surface of this combination are r_1 and r_2. Which of the following is a correct expression for radius of curvature of the common surface?

(a) $\frac{r_1 r_2(\beta_A - \beta_B)}{r_2\beta_A - r_1\beta_B}$

(b) $\frac{r_1 r_2(\beta_A - \beta_B)}{r_2\beta_A - r_1\beta_B} + \frac{r_1 r_2(\mu_{A0} - \mu_{B0})}{r_2\mu_{A0} - r_1\mu_{B0}}$

(c) $\frac{r_1 r_2(\beta_A - \beta_B)}{r_2\beta_A + r_1\beta_B}$

(d) $\frac{r_1 r_2(\beta_A - \beta_B)}{r_2\beta_A - r_1\beta_B} - \frac{r_1 r_2(\mu_{A0} - \mu_{B0})}{r_2\mu_{A0} - r_1\mu_{B0}}$

27. In the middle of a calm lake, a radio receiver is installed on a pole at a height 4.0 m above water level. The receiver is used to track radio signals from a satellite orbiting the earth. As the satellite rises above the horizon, intensity of the signals at the receiver varies periodically, It is maximum, when the satellite is 3° above the horizon and then again when the satellite

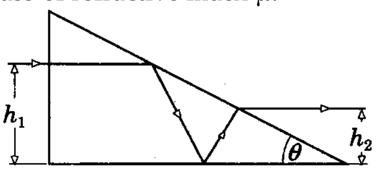
is 6° above the horizon. Wavelength of the satellite signals is closest to
(a) 24 cm (b) 36 cm
(c) 42 cm (d) 48 cm

28. While travelling by a train or by a bus, if we look outside, we observe some effects. These effects and some facts possibly explaining these effects are given in the first and the second columns of the following table. Suggest suitable matches.

Column I	Column II
(a) Nearby objects appear moving past faster than distant objects.	(p) Human eye senses the direction from which light enters it.
(b) Extremely distant objects appear moving along with us.	(q) It cannot resolve two points if they subtend an angle less than one minute
	(r) Persistence of eye is 0.1 s.

(a) a → r, b → q and p
(b) a → q, b → p and r
(c) a → p, b → p and q
(d) a → p, b → q and r

Questions 29 to 31 are based on the following.
Consider the setup shown in the figure, which uses a right-angled prism to transmit a horizontal incident ray. This device is known as anamorphic de-magnifier. During its passage through the prism, the ray experiences total internal reflection (TIR) twice and then exits as shown in the figure. The prism is made from a glass of refractive index μ.

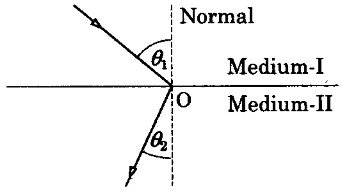


29. If the emerging ray propagates horizontally, which of the following is a correct expression for refractive index μ?
(a) $\mu = \dfrac{\sin\theta}{\sin 3\theta}$ (b) $\mu = \dfrac{\sin\theta}{\cos 3\theta}$
(c) $\mu = \dfrac{\cos\theta}{\sin 3\theta}$ (d) $\mu = \dfrac{\cos\theta}{\cos 3\theta}$

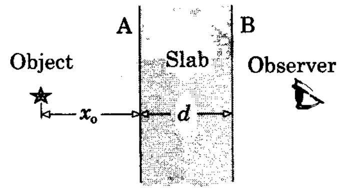
30. Range of values of tip angle θ for the device to work as anamorphic de-magnifier is
(a) $\frac{1}{3}\cos^{-1}\left(\frac{1}{\mu}\right) < \theta < \frac{1}{2}\sin^{-1}\left(\frac{1}{\mu}\right)$
(b) $\frac{1}{3}\sin^{-1}\left(\frac{1}{\mu}\right) < \theta < \frac{1}{2}\cos^{-1}\left(\frac{1}{\mu}\right)$
(c) $\frac{1}{3}\sin^{-1}\left(\frac{1}{\mu}\right) < \theta < \frac{1}{2}\sin^{-1}\left(\frac{1}{\mu}\right)$
(d) $\frac{1}{3}\cos^{-1}\left(\frac{1}{\mu}\right) < \theta < \frac{1}{2}\cos^{-1}\left(\frac{1}{\mu}\right)$

31. Ratio of height of the incoming ray from the base of the prism to that of the emerging ray is defined as the vertical de-magnification ratio. Which of the following is a correct expression for the vertical de-magnification ratio?
(a) $\dfrac{\sin\theta}{\sin 3\theta}$ (b) $\dfrac{\cos\theta}{\cos 3\theta}$
(c) $\dfrac{2\mu}{1+\mu}$ (d) $\dfrac{\mu}{1+2\mu}$

Questions 32 to 34 are based on the following.
If Snell's law is found valid for two mediums, whose refractive indices have opposite signs, the incident and the refracted rays must remain on the same side of the normal at the point of incidence. In the figure is shown a ray crossing the interface between two mediums I and II. The ray makes angles θ_1 and θ_2 with normal in the medium-I and II. The refractive indices of the mediums μ_1 and μ_2 have opposite signs.
Snell's law is expressed for the above situation as usual by the equation $\mu_1 \sin\theta_1 = \mu_2 \sin\theta_2$. Therefore, to satisfy this equation, the angles θ_1 and θ_2 must also have opposite signs.



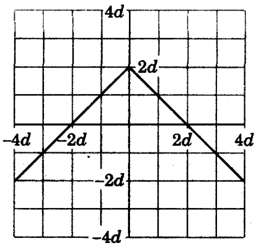
32. A self-luminous point object placed at a distance x_o from a slab of transparent material of negative refractive index is viewed through the slab as shown in the figure. Thickness of the slab is d, refractive index of material of the slab with respect to the outside medium is μ = –1.
For different moduli of values of x0 and d the observer may find real or virtual image of the object. Which of the following statements is true?

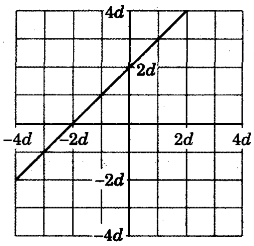


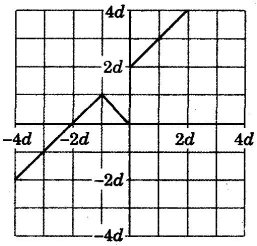
(a) If x_o > d, image is virtual and for x_o < d image is real.
(b) If x_o < d, image is virtual and for x_o> d image is real.
(c) If $x_o \le$ d, image is virtual and for x_o > d image is real.
(d) If x_o > d, image is virtual and for $x_o \le$ d image is real.

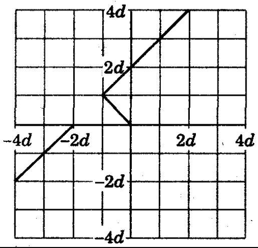
33. Suppose a virtual object instead of a real object is at a distance x_o from the surface A of the slab. Now which of the following statements is true?
(a) For the cases x_o < d and x_o > d a real and erect image is formed outside the slab.
(b) For the cases x_o < d and x_o > d a real and inverted image is formed outside the slab.
(c) If x < d a real image is formed outside the slab and for x_o > d a virtual image is formed inside the slab.
(d) If x_o < d a real image is formed and for x_o > d a virtual image is formed and in both the cases the image is outside the slab.

34. Distances x_o and x_i of the object and the final image are measured from the face A of the slab. The Cartesian sign conventions are also followed. Which one of the following graphs correctly represents relationship between x_o as abscissa and x_i as ordinate?

(a) 

(b) 

(c) 

(d) 

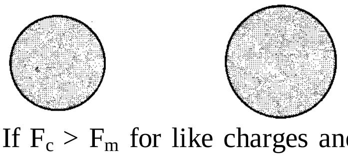
Electrostatics

35. When identical point charges are placed at the vertices of a cube of edge length a, each of them experiences a net force of magnitude F. Now these charges are placed on the vertices of another cube of edge length b. What will magnitude of the net force on any of the charges be? These cubes are simply geometrical constructs and not made of any matter.

(a) $\frac{aF}{b}$ (b) $\frac{bF}{a}$

(c) $\frac{a^2F}{b^2}$ (d) $\frac{b^2F}{a^2}$

36. Two charged spheres are kept at a finite centre-to-centre spacing as shown in the figure. The force of electrostatic interaction between them is first calculated assuming them point like charges at their respective centres and then force is measured experimentally. If the calculated and the measured values are F_c and F_m respectively, which of the following conclusion can you certainly draw?



(a) If $F_c > F_m$ for like charges and $F_c < F_m$ for unlike charges, both the spheres must be made of insulating materials.

(b) If $F_c > F_m$ for like charges and $F_c < F_m$ for unlike charges, both the spheres must be made of conducting materials.

(c) Irrespective of their materials, $F_c < F_m$ for like charges and $F_c > F_m$ for unlike charges.

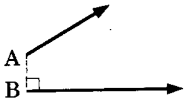
(d) Irrespective of their materials, $F_c > F_m$ for like charges and $F_c < F_m$ for unlike charges.

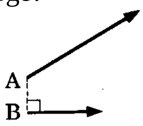
37. A thin conducting ring is ruptured when it is given a charge q. Consider another thin conducting ring, radius of which is n times and tensile strength is k times of the former ring. How much maximum charge can this second ring be given without rupturing?

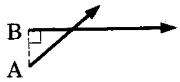
(a) < qnk (b) < $qn\sqrt{k}$

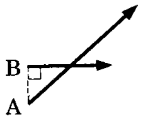
(c) < $qn^2\sqrt{k}$ (d) Insufficient information

38. Each of the following figures shows electric field vectors at two points A and B in an electric field. In which figure or figures can the illustrated field be created by a single point charge?

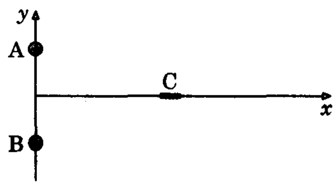
(a) 

(b) 

(c) 

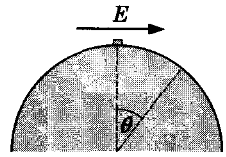
(d) 

39. Two equal point-like positive charges A and B are fixed on the y-axis equidistant from the origin. What can you say for the net electrostatic force on a small electrically neutral rod placed on the x-axis as shown in the figure?



(a) No force at all.
(b) It points away from the origin.
(c) It points towards the origin.
(d) Information is insufficient.

40. A positively charged small disc is released on the top of fixed hemispherical frictionless dome in presence of a uniform horizontal electric field. If the disc leaves the dome after an angular displacement $\theta = \sin^{-1}(3/5)$, find ratio of gravitational and electrostatic forces on the disc. Assume that the dome does not exhibit any electrical property.

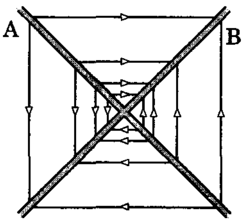


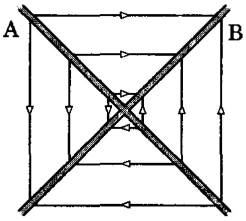
(a) 4/3 (b) 3/4 (c) 9/2 (d) 12

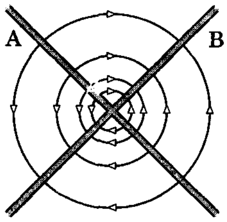
41. If a dipole of dipole moment $p\hat{i}$ is placed at point (0, y) and a point charge at the origin of a coordinate system, net electric field at point (x, $x + y$) vanishes. If x and y both are positive, the coordinate y is equal to

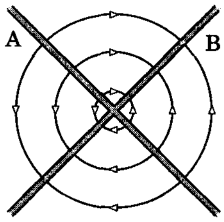
(a) x (b) $2x$ (c) $2.5x$ (d) $3x$

42. Two infinitely large planes A and B intersect each other at right angles and carry uniform surface charge densities $+\sigma$ and $-\sigma$. Which of the following figures best represents electric field lines?

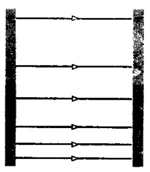
(a) 

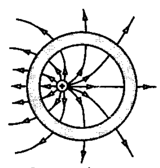
(b) 

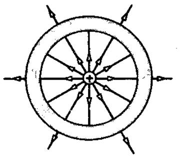
(c) 

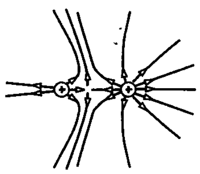
(d) 

43. In the following figures, electric field lines of some electrostatic fields are shown. Which of them are incorrect representations?

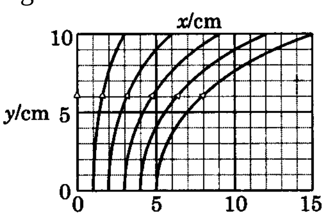
(a) 
Two infinitely large charged layers

(b) 
Point charge in a neutral conducting shell

(c) 
Point charge in a neutral conducting shell

(d) 
Two unequal point charges

44. Electric field lines of a portion of an electric field that is symmetrical with respect to rotation about y-axis are shown in the figure. A charge particles stays in equilibrium at point (0, 10). If modulus of charge of the particle is changed gradually till it shifts to another equilibrium position (0, 0), estimate fractional change in the charge modulus.



(a) 1/3 (b) 2/3 (c) 1/9 (d) 8/9

45. In the figure, a line of electric field created by two point charges q_1 and q_2 is shown. If it is known that $q_1 = 1\mu C$, the charge q_2 is closest to

(a) –2 μC (b) –4 μC
(c) –6 μC (d) –8 μC

46. A conducting shell of radius R has charge Q. Electrostatic force between two parts of the shell which are on either sides of a plane that is at a distance r (r < R) from the centre of the shell is

(a) $\frac{Q^2}{32\pi\varepsilon_0 R^2}\left(1+\frac{r}{R}\right)$ (b) $\frac{Q^2}{32\pi\varepsilon_0 R^2}\left(1-\frac{r}{R}\right)$

(c) $\frac{Q^2}{32\pi\varepsilon_0 R^2}\left(1+\frac{r^2}{R^2}\right)$ (d) $\frac{Q^2}{32\pi\varepsilon_0 R^2}\left(1-\frac{r^2}{R^2}\right)$

47. A half cylinder of radius R and length L >> R is formed by cutting a cylindrical pipe made of an insulating material along a plane containing its axis. The rectangular base of the half cylinder is closed by a dielectric plate of length of length L and width 2R. A charge Q on the half cylinder and a charge q on the dielectric plate are uniformly sprinkled. Electrostatic force between the plate and the half cylinder is closest to

(a) $\frac{qQ}{2\varepsilon_0 RL}$ (b) $\frac{qQ}{2\pi\varepsilon_0 RL}$

(c) $\frac{qQ}{4\varepsilon_0 RL}$ (d) $\frac{qQ}{8\varepsilon_0 RL}$

48. A conducting sphere of radius r_1 is surrounded by a dielectric layer of outer radius r_2 and dielectric constant ε_r. If the conducting sphere is given a charge q, determine surface density of polarization charges on the outer surface of the dielectric layer.

(a) $\frac{\varepsilon_r q}{4\pi r_2^2}$ (b) $\frac{q}{4\pi\varepsilon_r r_2^2}$

(c) $\frac{(\varepsilon_r - 1)q}{4\pi r_2^2}$ (d) $\frac{(\varepsilon_r - 1)q}{4\pi\varepsilon_r r_2^2}$

49. Due to a point charge, potential and electric field at a point A are 7 V and 3 V/m respectively and electric field at a point B is less than 3 V/m. Now magnitude of the charge is tripled. If electric field at B becomes 3 V/m, potential at B will become closest to
(a) 7 V (b) 12V
(c) 21V (d) Insufficient information

50. In another world, instead of the Coulomb's law, electric force $\vec{F}$ on a point like charge q due to another point like charge Q is found to obey the following law.

$$\vec{F} = \frac{Qq\left(1-\sqrt{\alpha r}\right)}{4\pi\varepsilon_0 r^3}\vec{r}$$

Here α is a positive constant and $\vec{r}$ is the position vector of charge relative to the charge Q.
(a) Electric field due to a point charge Q is $\vec{E} = \frac{Q\left(1-\sqrt{\alpha r}\right)}{4\pi\varepsilon_0 r^3}\vec{r}$

(b) Line integral of this electric field $\oint \vec{E}\cdot d\vec{l}$ over a closed path is also zero as in our world.

(c) Gauss' law $\oint \vec{E}\cdot d\vec{s} = \frac{q_{\text{enclosed}}}{\varepsilon_0}$ also holds true for this electric field.
(d) All the above statements are true but this electric field is not conservative.

51. A cube made of an insulating material has uniform charge distribution throughout its volume. Assuming electric potential due to this charged cube at infinitely distant places to be zero, potential at the centre is found to be V_0. What is electric potential at one of its corners?
(a) V_0 (b) $V_0/2$ (c) $V_0/4$ (d) $V_0/8$

52. Consider a cube as shown in the figure-I; with uniformly distributed charge in its entire volume. Intensity of electrical field and potential at one of its vertex P are E_0 and V_0 respectively. A portion of half the size (half edge length) of the original cube is cut and removed as shown in the figure-II. Find modulus of electric field and potential at the point P in the new structure.

Figure-I

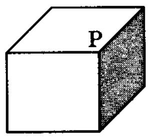
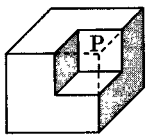


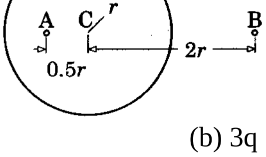
Figure-II



(a) $\frac{E_0}{2}$ and $\frac{3V_0}{4}$ (b) $\frac{3E_0}{4}$ and $\frac{V_0}{2}$
(c) $\frac{3E_0}{4}$ and $\frac{7V_0}{8}$ (d) $\frac{7E_0}{8}$ and $\frac{7V_0}{8}$

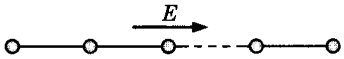
53. Electrostatic potential V has been measured everywhere outside a spherical body of radius R made of unknown material. It was found that the potential is spherically symmetric, i.e. depends only on the distance r from the centre of the sphere as given by the expression V = A/r, where A is a constant. No measurement of the potential inside the sphere has been done. What can you conclude for charge distribution of the body?
(a) It must be uniform.
(b) It may be nonuniform but must have spherical symmetry.
(c) It may be uniform or nonuniform without any spherical symmetry.
(d) To predict charge distribution precisely we need to know electric field outside the sphere.

54. Consider a thin conducting shell of radius r carrying total charge q. Two point charges q and 2q are placed on points A and B, which are at distances 0.5r and 2r from the centre C of the shell respectively. If the shell is earthed, how much charge will flow to the earth?



(a) 2q (b) 3q
(c) 4q
(d) More than 2q and less then 3q

55. A straight chain consisting of n identical metal balls is at rest in a region of free space as shown. In the chain, each ball is connected with adjacent balls by identical conducting wires. Length l of a connecting wire is much larger than the radius r of a ball. A uniform electric field E pointing along the chain is switched on in the region. Find magnitude of induced charges on one of the end ball.



(a) $2\pi\varepsilon_0 rnlE$ (b) $2\pi\varepsilon_0 r(n-1)lE$
(c) $4\pi\varepsilon_0 r(n-1)lE$ (d) $4\pi\varepsilon_0 (n-1)^2 l^2 E$

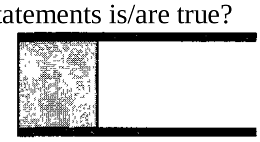
56. Small identical balls are attached at each end of a spring of force constant k = 200 N/m and relaxed length l = 20 cm. Unknown amount of charges are gradually transferred to the balls in unequal amounts until the spring length becomes twice of its relaxed length. What amount of work must be done by an external agency in slowly compressing the spring back to its relaxed length?
(a) 8 J (b) 12 J (c) 16J (d) 20 J

57. Electrostatic potential V at a point on circumference of a circular layer of uniform charge and radius r is given by equation V = 4σr, here u is surface charge density in the layer. Which of the following expression correctly represents electrostatic energy stored in the electric field of a similar charge layer of radius R?
(a) $\frac{1}{3}\pi\sigma^2 R^3$ (b) $\frac{2}{3}\pi\sigma^2 R^3$
(c) $\frac{4}{3}\pi\sigma^2 R^3$ (d) $\frac{8}{3}\pi\sigma^2 R^3$

58. Three identical electric dipoles are arranged parallel to each other at equal separations as shown in the figure. The separation between the charges of a dipole is negligible as compared to the separation between the dipoles. In the given configuration, total electrostatic interaction energy of these dipoles is U_0. Now one of the end dipole is gradually reversed, how much work is done by the electric forces?

(a) $\frac{17U_0}{18}$ (b) $-\frac{17U_0}{18}$
(c) $\frac{18U_0}{17}$ (d) $-\frac{18U_0}{17}$

59. A parallel plate capacitor of capacitance C_0 is charged to a voltage V and then the battery is disconnected. A dielectric covering one third area of each plate is now inserted as shown in the figure If charges on the capacitor plates get redistributed such that the portions covered with dielectric and not covered with the dielectric share equal amounts of charge, which of the following statements is/are true?



(a) Dielectric constant of the dielectric is 2.0.
(b) Charge appearing due to polarization on the surface of the dielectric is $0.25C_0V$.

(c) Force of electrostatic interaction between portions of the plates covered with dielectric is equal to that between uncovered portions.
(d) Force of electrostatic interaction between the plates after insertion of the dielectric becomes 9/8 times of its value before insertion of the dielectric.

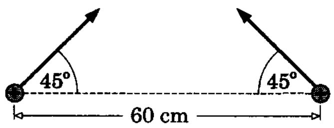
60. A flat air capacitor C consists of two large plates that are close to each other. Initially, one of the plates was not charged, while the other had charge Q. If entire space between the plates is filled with a slab of finite electrical resistance, estimate total amount of energy lost in the slab.

(a) $\frac{Q^2}{2C}$ (b) $\frac{Q^2}{8C}$
(c) $\frac{3Q^2}{8C}$ (d) $\frac{7Q^2}{8C}$

61. Two particles each of mass 100 g and charge 10 μC are released on a horizontal plane at a distance 1.0 m from each other. Coefficient of friction between the particles and the plane is 0.1 and acceleration of free fall is 10 m/s^2. Maximum speed acquired by the particles after they are released is closest to

(a) 2.0 m/s (b) 2.8 m/s
(c) 3.0 m/s (d) 4.2 m/s

62. Two identical point charges are moving in free space, when they are 60 cm apart; their velocity vectors are equal in modulus and make angles of 45° from the line joining them as shown in the figure. If at this instant, their total kinetic energy is equal to their potential energy, what will be the distance of closest approach between them?



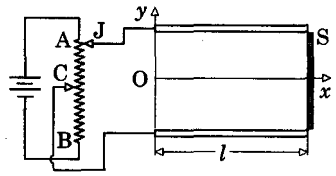
(a) 20 cm (b) 30 cm
(c) 40 cm (d) 45 cm

63. A thin disk of radius R is held closing the opening of a thin hemispherical shell of the same radius. Both the bodies are made of insulating materials and have uniform charges of surface charge density σ each. The plate is released keeping the shell fixed. How much maximum kinetic energy will the plate acquire after it is released?

(a) $\frac{\pi R^3\sigma^2}{8\varepsilon_0}$ (b) $\frac{\pi R^3\sigma^2}{4\varepsilon_0}$
(c) $\frac{\pi R^3\sigma^2}{2\varepsilon_0}$ (d) Insufficient information

Questions 64 to 66 are based on the following

Electrons (mass m and charge e) can be projected with a certain velocity from a point O between two parallel plate like electrodes separated by a distance d as shown in the figure. The bottom plate is connected to midpoint C of a rheostat, while the upper plate is connected to the rheostat through a sliding jockey J. The end terminals A and B of the rheostat are connected across an ideal battery of electromotive force V. When the jockey is held at C, electrons move along the *x*-axis that is parallel to the plates and hit a phosphorescent screen S in time T_0. Distance d between the electrodes is large enough so that none of the electrons strikes the electrodes. Ignore magnetic effects and electromagnetic radiations.



64. In a trial, the jockey J is held at A and an electron is projected. A time interval $0.5T_0$ after the electron is projected, the jockey is suddenly made to jump to the end B. Where on the screen does the electron make a spot?

(a) On the *x*-axis. (b) $\frac{eVT_0^2}{8md}$ above the *x*-axis.
(c) $\frac{eVT_0^2}{8md}$ below the x-axis.
(d) None of these

65. In second trial, the jockey J is made to slide from C to A and then back to C with the same speed in a total time interval T_0. Where will the electron hit the screen?

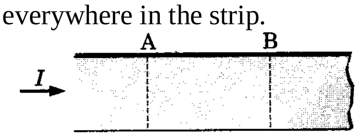
(a) On the *x*-axis with velocity $\vec{v} = \frac{l}{T_0}\hat{i}$.
(b) On the *x*-axis with velocity $\vec{v} = \frac{l}{T_0}\hat{i} - \frac{eVT_0}{4md}\hat{j}$.
(c) Above the *x*-axis with velocity $\vec{v} = \frac{l}{T_0}\hat{i} + \frac{eVT_0}{4md}\hat{j}$.
(d) Below the *x*-axis with velocity $\vec{v} = \frac{l}{T_0}\hat{i} - \frac{eVT_0}{4md}\hat{j}$.

66. In third trial, the jockey is made to slide from A to B with a constant speed in the time interval T_0. Where will the electron hit the screen?

(a) On the *x*-axis with velocity $\vec{v} = \frac{l}{T_o}\hat{i}$.
(b) Above the *x*-axis with velocity $\vec{v} = \frac{l}{T_o}\hat{i}$.
(c) Below the *x*-axis with velocity $\vec{v} = \frac{l}{T_o}\hat{i}$.
(d) On the *x*-axis with velocity $\vec{v} = \frac{l}{T_o}\hat{i} + \frac{eVT_o}{2md}\hat{j}$.

ELECTRIC CURRENT

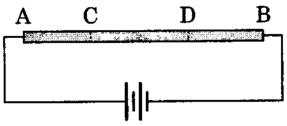
67. A constant current I flows in a strip-line conductor, resistivity of which increases monotonically in the direction of the current flow. If resistivities at cross-sections A and B are ρ_A and ρ_B, find excess charge accumulated in the section AB. Permittivity of free space is ε_0 and relative permittivity of material of the strip is everywhere in the strip.



(a) $\varepsilon_0(\rho_B - \rho_A)I$ (b) $\varepsilon_0\varepsilon_r(\rho_B - \rho_A)I$
(c) $\varepsilon_0(\varepsilon_r - 1)(\rho_B - \rho_A)I$ (d) $\varepsilon_0(\varepsilon_r^2 - 1)(\rho_B - \rho_A)I$

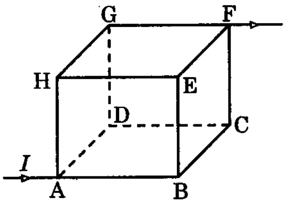
68. Under which of the following conditions, resistance of a cylindrical specimen of an Ohmic material is least affected by small temperature variations.
(a) Temperature coefficient of resistivity is greater than that of linear expansion.
(b) Temperature coefficient of resistivity is lesser than that of linear expansion.
(c) Temperature coefficient of resistivity is equal to that of linear expansion.
(d)Temperature coefficient of resistivity is negligible as compared to that of linear expansion.

69. A homogeneous rod AB of uniform cross-section is connected across a battery. By some arrangement (not shown in the figure), the section CD of the rod is being uniformly heated. What can you conclude regarding temperature distribution in the rod?



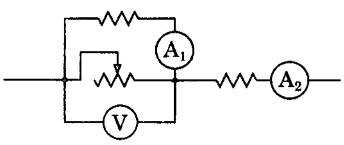
(a) Temperatures in all the three sections will be uniform with the highest value in the section CD and equal lower values in the sections AC and DB.
(b) Temperatures in all the three sections will be uniform with the highest value in the section AC, the lowest value in the section DB and an intermediate value in the section CD.
(c) Temperatures in all the three sections will be uniform with the highest value in the section CD, the lowest value in the section DB and an intermediate value in the section AC.
(d) Temperature distribution in all the three sections will be non-uniform with location of the highest temperature nearer to D in the section CD.

70. A closed cubical box is made by a thin conducting sheet. When its diagonally opposite corners are connected across a battery, it draw a current I from the battery. Find current flowing across the edge BE.



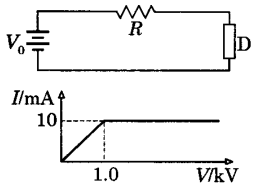
(a) I/3 (b) I/6
(c) I/9 (d) Between I/6 and I/3

71. In the figure is shown a part of a large network. If resistance of the rheostat is increased, how will the readings I_1 and I_2 of the ammeters A_1 and A_2 respectively and the reading of the voltmeter V change?



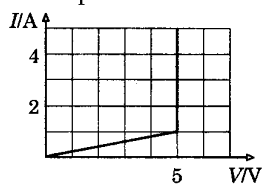
(a) I_1 and I_2 will decrease and V increase.
(b) I_1 will decrease and I_2 and V increase.
(c) I_2 will decrease and I_1 and V increase.
(d) It is sure that I_2 will decrease but nothing can be predicted about I_1 and V from the given information.

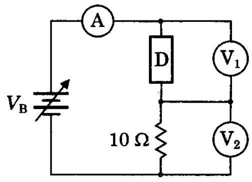
72. Volt-ampere (V-i) characteristics of an unknown device D connected in a circuit in series with a resistance and a battery is shown in the figure. If value of the resistance is R = 300 kΩ and terminal voltage of the battery is V_0 = 5 kV, find potential drop across the device.

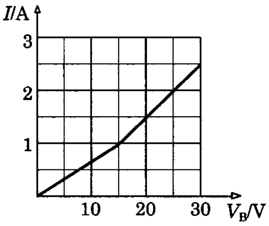


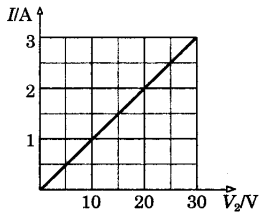
(a) 1.0 kV (b) 2.0 kV
(c) 3.0 kV (d) 4.0 kV

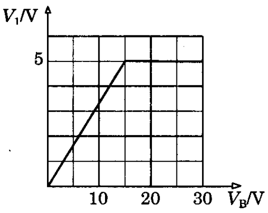
73. Volt-ampere (V-I) characteristic of a nonlinear device D and corresponding circuit used are shown in the adjoining figures. Voltage V_B of the battery is made to vary from zero to 30 V and voltage V_1 across the device D, voltage V_2 across the 10 Ω resistor and current I supplied by the battery are measured by ideal voltmeters V_1 and V_2 and an ideal ammeter A. Which of the following graph/graphs represent correct relationship?

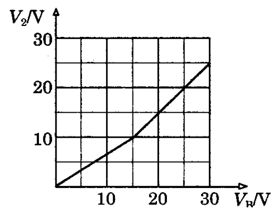




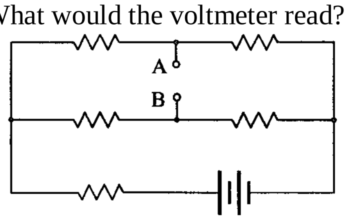
(a)


(b)


(c)


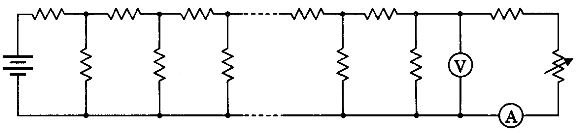
(d)


74. A network shown in the figure consists of a battery and five unknown resistors. When an ideal ammeter is connected between the terminals A and B, its reading is 4 A and when a resistance of 3 Ω is connected in series with the ammeter its reading becomes 2 A. Now the ammeter and the resistance are disconnected and an ideal voltmeter is connected between the terminals A and B. What would the voltmeter read?



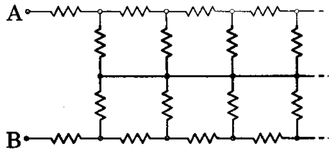
(a) 6 V (b) 10V (c) 12V (d) 18V

75. The network shown consists of an ideal battery, an ideal voltmeter V, an ideal ammeter A, several resistors of different values and a rheostat. If resistance of the rheostat is increased by a finite amount, how will the readings of the voltmeter and ammeter change?



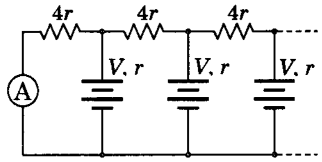
(a) Both will decrease.
(b)Voltmeter reading will decrease and ammeter reading will increase.
(c)Voltmeter reading will increase and ammeter reading will decrease.
(d)Voltmeter reading will not change but ammeter reading will decrease.

76. The circuit shown in the diagram extends to the right into infinity. Each branch resistance is denoted by r. What is the resistance between the terminals A and B?



(a) $\frac{(\sqrt{5}+1)r}{2}$ (b) $\frac{(\sqrt{5}-1)r}{2}$
(c) $(\sqrt{5}+1)r$ (d) $(\sqrt{5}-1)r$

77. The circuit shown in the diagram extends to the right into infinity. Each battery has electromotive force V (unknown) and internal resistance r (known). Each resistor has resistance 4r. Reading of the ideal ammeter shown in the diagram is *I*. Find the value of V in terms of *I* and r.



(a) $(2-2\sqrt{2})Ir$ (b) $(2+2\sqrt{2})Ir$
(c) 4.5 *Ir* (d) 3.0 *Ir*

78. An ideal battery of electromotive force $\mathscr{E}$ is connected in series with an ammeter and a voltmeter of unknown internal resistances. If a certain resistance is connected in parallel with the voltmeter, the voltmeter and the ammeter readings becomes 1/η and η times of their respective initial readings. What is the initial reading of the voltmeter?

(a) $\frac{\mathscr{E}}{(\eta+1)}$ (b) $\frac{\eta\mathscr{E}}{(\eta+1)}$
(c) $\frac{\eta\mathscr{E}}{(\eta-1)}$ (d) $\frac{(\eta+1)\mathscr{E}}{\eta}$

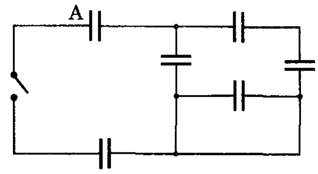
79. Two identical conducting spheres each of radius a are placed at centre to centre separation d (d >> a). They are kept in a homogeneous medium of permittivity ε and resistivity ρ. Which one of the following is a correct expression of resistance between them?

(a) $\frac{\rho}{2\pi a}$ (b) $\frac{\rho}{4\pi a}$
(c) $\frac{\rho d}{2\pi a^2}$ (d) $\frac{\rho d}{4\pi a^2}$

80. An air-filled parallel-plate capacitor with the plate area A is connected to a battery of electromotive force V and negligible internal resistance. One of the plates is made to vibrate so that the distance between the plates varies as d = d_0 + *a* cos(ωt), where *a* << d_0. If instantaneous current in the circuit reaches a maximum value of I_0, the maximum possible amplitude of vibrations a is

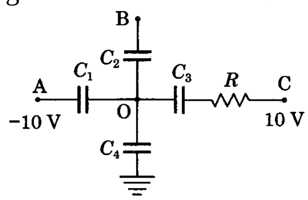
(a) $\frac{aI_0}{VA\omega\varepsilon_0}$ (b) $\frac{I_0 d_0}{VA\omega\varepsilon_0}$
(c) $\frac{I_0 d_0^2}{VA\omega\varepsilon_0}$ (d) $\frac{I_0 d_0}{V\sqrt{A}\omega\varepsilon_0}$

81. In the circuit shown, all capacitors are identical, initially the switch is open and only the capacitor A is charged. After the switch is closed and a steady-state is established, charge on the capacitor A becomes 5.0 μC. Initial charge on this capacitor is closest to



(a) 7.5 μC (b) 8.0 μC
(c) 13.3 μC (d) 15.0 μC

82. The figure shows part of a large network in which potentials of some of the points are shown. Each capacitor has a capacitance 5 μF. Which of the following statements is/are true?



(a) From the given information, potential of point O can be determined but that of B cannot be determined.
(b) From the given information, potential of both the points 0 and B cannot be determined.
(c) If charge on capacitor C_2 were also specified, potential of point O can be determined but that of B cannot be determined.
(d) If charge on capacitor C_2 were also specified, potentials of both the points O and B can be determined.

83. Two parallel plate capacitors of capacitances C and 2C consisting of plates of identical dimensions are connected with an ideal battery of terminal voltage V as shown in the figure-I. Now the capacitor smaller in volume is completely inserted into the larger capacitor and kept in symmetric position and then connection polarities of the plates are reversed as shown in the figure-II. Which one of the following statements is correct?

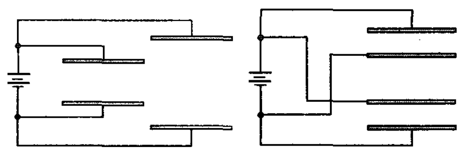
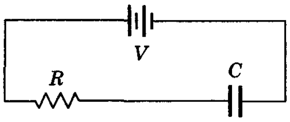


Figure-I **Figure-II**

(a) Charge flown through the battery is 8CV and it absorbs energy.
(b) Charge flown through the battery is 8CV and it delivers energy.
(c) Charge flown through the battery is 7CV and it absorbs energy.

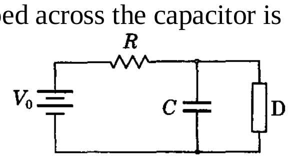
(d) Charge flown through the battery is 7CV and it delivers energy.

84. An air filled parallel plate capacitor of capacitance C is connected through a resistance R to an ideal voltage source of electromotive force V. A dielectric plate of dielectric constant k is inserted in the capacitor to occupy whole space between the plates. After a steady state is reached, the plate is quickly pulled out. Which of the following is correct expression for heat generated in the resistance until a steady state is reached again?



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

85. In the circuit shown, the device D has a property that, if initially non-conducting, it remains non-conducting until voltage across it rises to a value V_1 (< V_0). It then rapidly discharges the capacitor until the voltage across it drops to a negligibly small value, where upon it returns to a non-conducting state. The voltage developed across the capacitor is



(a) periodic with time period RC.

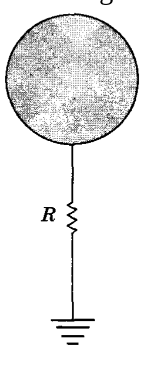
(b) periodic with time period $RC\ln\left(\frac{V_0}{V_1}\right)$.

(c) periodic with time period $RC\ln\left(\frac{V_0}{V_0-V_1}\right)$.

(d) periodic with time period $RC\ln\left(\frac{V_0^2}{V_1(V_0-V_1)}\right)$.

Questions 86 and 87 are based on the following.

A conducting balloon of radius *a* is charged to a potential V_0 and held at a large height above the earth surface. The large height of the balloon from the earth ensures that charge distribution on the surface of the balloon remains unaffected by the presence of the earth. It is earthed through a resistance R and a valve is opened. The gas inside the balloon escapes through the valve and the size of the balloon decreases. The rate of decrease in radius of the balloon is controlled in such a manner that potential of the balloon remains constant. Assume electric permittivity of the surrounding air equal to that of free space (ε_0) and charge' does not leak to the surrounding air.



86. Time rate at which radius r of the balloon changes is best represented by the expression

(a) $\frac{1}{4\pi\varepsilon_0 R}$ (b) $-\frac{1}{4\pi\varepsilon_0 R}$

(c) $\frac{r}{4\pi\varepsilon_0 aR}$ (d) $-\frac{r}{4\pi\varepsilon_0 aR}$

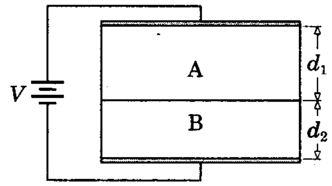
87. How much heat is dissipated in the resistance R until radius of the balloon becomes half?

(a) $0.5\pi\varepsilon_0 aV_0^2$ (b) $\pi\varepsilon_0 aV_0^2$

(c) $2\pi\varepsilon_0 aV_0^2$ (d) $4\pi\varepsilon_0 aV_0^2$

Questions 88 and 89 are based on the following.

A parallel plate capacitor is filled with two layers of different materials A and B as shown in the figure on the next page. The material A has dielectric constant k_1 and conductivity σ_1 and the material B has dielectric constant k_2 and conductivity σ_2. The capacitor is connected across an ideal battery of terminal voltage V. Permittivity of free space is ε_0



88. Electric field in the material A is

(a) $\frac{V\sigma_1}{d_1\sigma_1 + d_2\sigma_2}$ (b) $\frac{V\sigma_2}{d_1\sigma_1 + d_2\sigma_2}$

(c) $\frac{V\sigma_1}{d_1\sigma_2 + d_2\sigma_1}$ (d) $\frac{V\sigma_2}{d_1\sigma_2 + d_2\sigma_1}$

89. What is the total surface charge density on the interface of the two materials?

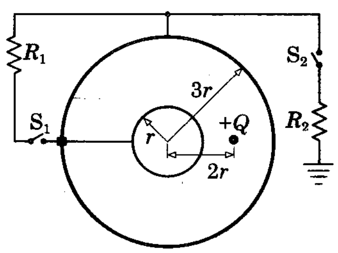
(a) $\frac{\varepsilon_0 V(k_1 - k_2)}{d_1 k_2 + d_2 k_1}$ (b) $\frac{\varepsilon_0 V(\sigma_1 - \sigma_2)}{d_1\sigma_2 + d_2\sigma_1}$

(c) $\frac{\varepsilon_0 V(\sigma_1 k_2 - \sigma_2 k_1)}{d_1\sigma_2 + d_2\sigma_1}$

(d) $\frac{V}{\varepsilon_0 d_1 d_2}\left[\frac{d_1}{d_1+d_2} - \frac{d_2}{d_1+d_2}\right]$

Questions 90 and 91 are based on the following.

Consider two electrically neutral concentric conducting thin spherical shells of radii r and 3r. A particle of positive charge Q is fixed at a distance 2r from the common centres of the shells. The inner shell can be electrically connected to the outer shell through a resistance R_1 with the help of a switch S_1 and the outer shell can be grounded through a resistance R_2 with the help of another switch S_2 as shown in the figure.



90. How much total heat is dissipated in the resistance R_1 after the switch S_1 is closed keeping the switch S_2 open until a steady state is reached?

(a) $\frac{Q^2}{48\pi\varepsilon_0 r}$ (b) $\frac{Q^2}{96\pi\varepsilon_0 r}$

(c) $\frac{Q^2}{192\pi\varepsilon_0 r}$ (d) $\frac{Q^2}{384\pi\varepsilon_0 r}$

91. When a steady state is reached after closing the switch S_1, the other switch S_2 is closed. How much total heat is dissipated after the switch S_2 is closed until a new steady state is reached?

(a) Heat dissipated in each resistor is $\frac{Q^2}{48\pi\varepsilon_0 r}$.

(b) Heat dissipated in R_1 is $\frac{Q^2}{24\pi\varepsilon_0 r}$ and no heat is dissipated in R_2.

(c) Heat dissipated in R_2 is $\frac{Q^2}{24\pi\varepsilon_0 r}$ and no heat is dissipated in R_1.

(d) Both the resistors dissipate different amounts of heat, total amount of which is $\frac{Q^2}{24\pi\varepsilon_0 r}$.

Magnetic Effects of Electric Current

92. Current I flowing along edges of one face of a cube as shown in the figure-I, produces magnetic field $\vec{B} = B_0\hat{j}$ at the centre of the cube. Consider another identical cube, where the current I flows along the path shown in the figure-Il. How much magnetic field exists at the centre of the second cube?

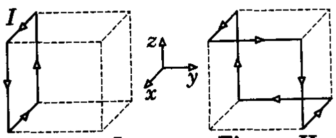


Figure-I Figure-II

(a) Zero (b) $B_0\left(\hat{i}+\hat{j}+\hat{k}\right)$

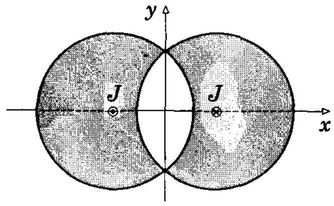
(c) $B_0\left(-\hat{i}+\hat{j}+\hat{k}\right)$ (d) $B_0\left(-\hat{i}+\hat{j}-\hat{k}\right)$

93. A parallel plate capacitor consists of square plates of edge length a separated by a distance d that is much smaller that the edge length. It is charged to a potential V and made to move with a constant velocity v directed along one of its edges. How much magnetic field exists inside the capacitor?

(a) $\frac{\mu_0\varepsilon_0 vV}{d}$ (b) $\frac{\mu_0\varepsilon_0 vV}{a}$

(c) $\frac{\mu_0\varepsilon_0 dvV}{a^2}$ (d) None of these

94. A long straight conductor has uniform cross-section in the shape of two identical overlapped circles with centre-to-centre spacing a. Material from overlapped section has been removed from entire length of the conductor and portions to the right and to the left of the y-z plane are insulated from each other. These portions carry uniform currents of current density $\boldsymbol{J}$ in the positive and negative z-directions respectively. Permeability of both the conductors is the same as that of vacuum. Which of the following statements best describes magnetic field in the empty space inside the composite conductor.



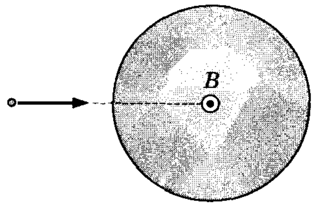
(a) It is non-uniform and points in the positive y-direction everywhere on the y-axis.

(b) It is non-uniform and points in the positive y-direction everywhere on the x and y-axes.

(c) It is uniform, points everywhere in the positive y-direction and has magnitude ½ $\mu_0 \boldsymbol{J}a$.

(d) It has different directions at different points but the same magnitude ½ $\mu_0 \boldsymbol{J}a$.

95. Several α-particles of different speeds enter a uniform magnetic field confined into a cylindrical region. If all the α-particles enter the field radially, what can you say about time intervals spent by them in the magnetic field?



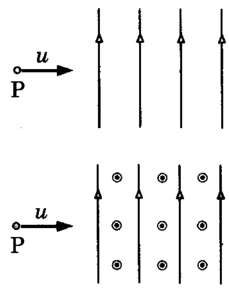
(a) Faster is the particle, lesser is the time.

(b) Slower is the particle, lesser is the time.

(c) Slower is the particle, greater is the time.

(d)The time is same for all the particles.

96. A positively charged particle P crosses a region of uniform electric field of intensity E. Velocity u of the particle at the entry on the left side of the region is perpendicular to the electric field as shown in the first figure. Speed of the particle at exit on the right side is v_1. Now the experiment is repeated with a uniform magnetic field of induction B superimposed on the electric field as shown in the second figure, keeping entry velocity of the particle unchanged. In this experiment, speed of the particle at exit on the right side is v_2. What can you conclude regarding the speeds v_1 and v_2?



(a) If $u < \frac{E}{B}$, then $v_2 < v_1$

(b) If $u = \frac{E}{B}$, then $v_2 < v_1$

(c) If $u = \frac{E}{B}$, then $v_2 = v_1$

(d) If $u > \frac{E}{B}$, then $v_2 < v_1$

97. A particle of mass m and charge q is moving with a constant speed in a region of space, where a uniform and constant magnetic field $\vec{B}$ and an electric field $\vec{E}$ coexist in mutually perpendicular horizontal directions in addition to gravitational field of intensity g. After the magnetic and electric fields are switched off, the minimum kinetic energy of the particle is observed to be half of the kinetic energy when all these fields were coexisting. What can you certainly conclude for component of velocity of the particle along the direction of the magnetic field?

(a) $\vec{0}$

(b) $\sqrt{\left(\frac{E}{B}\right)^2-\left(\frac{mg}{qB}\right)^2}$ pointing opposite to $\vec{B}$

(c) $\sqrt{\left(\frac{E}{B}\right)^2-\left(\frac{mg}{qB}\right)^2}$ pointing in the direction of $\vec{B}$

(d) $\sqrt{\left(\frac{E}{B}\right)^2-\left(\frac{mg}{qB}\right)^2}$ pointing either in direction of or opposite to $\vec{B}$

98. In a region of free space, where a uniform and constant electric field of intensity $\vec{E}$ and a magnetic field of induction $\vec{B}$ coexist, an electron projected with speed v in the positive x-direction, moves undeviated without change in speed. In addition, an electron projected with velocity v in the positive y-direction in this region; also, moves undeviated without change in speed. Which of the following conclusions can you make?

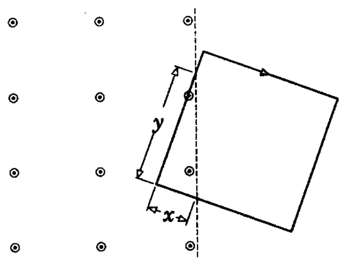
(a) $|\vec{E}| < v|\vec{B}|$

(b) $|\vec{E}| = v|\vec{B}|$

(c) The electric field is perpendicular to the x-y plane.

(d)The magnetic field is either at 45° or 135° with the positive x-direction.

99. A rigid square loop of side length l carrying an electric current is held motionless on a frictionless horizontal tabletop. A uniform magnetic field pointing upwards is switched on everywhere to the left of the dashed line as shown in the figure and then the loop is released. Considering different lengths of the side segments x and y ($x < y$), which of the following conclusions can you make?



(a) If $x<\frac{l}{2}$ and $y=\frac{l}{2}$, the loop starts rotating anticlockwise.

(b) If $x<\frac{l}{2}$ and $y<\frac{l}{2}$, the loop starts rotating anticlockwise.

(c) If $x<\frac{l}{2}$ and $y>\frac{l}{2}$, the loop starts rotating clockwise.

(d) If $x<\frac{l}{2}$ and $y>\frac{l}{2}$, more information is required to decide which way the loop starts rotating.

100. Two coaxial circular coils of radii a and b are separated by a large distance x and carry equal currents I. If $a >> b$, what is the force of mutual interaction between them.

(a) $\frac{\mu_0 I^2 a^2 b}{\left(a^2+x^2\right)^{1.5}}$ (b) $\frac{3\pi\mu_0 I^2 abx}{\left(a^2+x^2\right)^{1.5}}$

(c) $\frac{\pi\mu_0 I^2 a^3 b}{\left(a^2+x^2\right)^2}$ (d) $\frac{3\pi\mu_0 I^2 a^2 b^2 x}{2\left(a^2+x^2\right)^{2.5}}$

ANSWER

1. a	**2.** d	**3.** c	**4.** b	**5.** d
6. a	**7.** c	**8.** abcd	**9.** bc	**10.** b
11. c	**12.** acd	**13.** d	**14.** c	**15.** d
16. c	**17.** b	**18.** a	**19.** a	**20.** b
21. b	**22.** a	**23.** b	**24.** a	**25.** b
26. a	**27.** c	**28.** c	**29.** d	**30.** d
31. ad	**32.** d	**33.** a	**34.** b	**35.** c
36. d	**37.** b	**38.** ac	**39.** d	**40.** c
41. b	**42.** b	**43.** abc	**44.** d	**45.** d
46. d	**47.** d	**48.** d	**49.** b	**50.** ab
51. b	**52.** a	**53.** c	**54.** b	**55.** b
56. b	**57.** d	**58.** c	**59.** abd	**60.** b
61. a	**62.** c	**63.** c	**64.** b	**65.** c
66. b	**67.** a	**68.** c	**69.** d	**70.** b
71. c	**72.** b	**73.** abcd	**74.** c	**75.** c
76. c	**77.** b	**78.** b	**79.** a	**80.** c
81. b	**82.** bd	**83.** d	**84.** d	**85.** c
86. b	**87.** c	**88.** d	**89.** b	**90.** c
91. c	**92.** c	**93.** a	**94.** c	**95.** ac
96. abd	**97.** d	**98.** acd	**99.** abd	100.d

Self attempt problems : ....

Discussed with friends : ....

Discussed with faculty : ....