Physics

TARGET : JEE 2013

Home Assignment # 01

ALLEN CAREER INSTITUTE
KOTA (RAJASTHAN)
Path to Success

Corporate Office
ALLEN CAREER INSTITUTE
"SANKALP", CP-6, INDRA VIHAR, KOTA-324005
PHONE : +91 - 744 - 2436001, Fax : +91-744-2435003
E-mail: info@allen.ac.in Website: www.allen.ac.in

EXERCISE # O-1

1. A dielectric slab of thickness 'd' is inserted in the parallel plate capacitor whose negative plate is at x = 0 and positive plate is at x = 3d. The slab is equidistant from the plates. The capacitor is given some charge. As x goes from 0 to 3d.

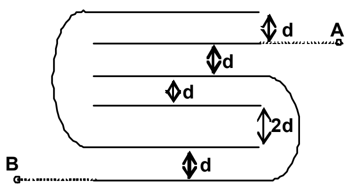
(A) the magnitude of the electric field remains the same

(B) the direction of the electric field remains the same

(C) the electric potential increases continuously

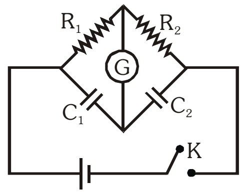
(D) the electric potential increases first, then decreases and again increases

2. Find equivalent capacitance between A and B. [Assume each conducting plate is having same dimensions and neglect the thickness of the plate, $\frac{\epsilon_0 A}{d} = 7\mu F$ where A is area of plates, A >> d]



(A) 7 μF (B) 11 μF (C) 12 μF (D) 13 μF

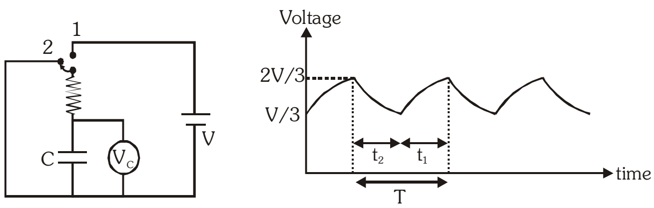
3. In the circuit, if no current flows through the galvanometer when the key K is closed, the bridge is balanced. The balancing condition for bridge is



(A) $\frac{C_1}{C_2} = \frac{R_1}{R_2}$ (B) $\frac{C_1}{C_2} = \frac{R_2}{R_1}$

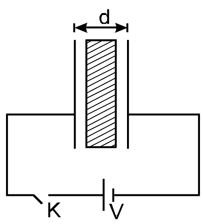
(C) $\frac{C_1^2}{C_2^2} = \frac{R_1^2}{R_2^2}$ (D) $\frac{C_1^2}{C_2^2} = \frac{R_2}{R_1}$

4. The switch in circuit shifts from 1 to 2 when $V_C > 2V/3$ and goes back to 1 from 2 when $V_C < V/3$. The voltmeter reads voltage as plotted. What is the period T of the wave form in terms of R and C?



(A) RC ℓn3 (B) 2RC ℓn 2 (C) $\frac{RC}{2}\ell n3$ (D) $\frac{RC}{3}\ell n3$

5. The area of the plates of the capacitor shown in figure is S. The dielectric constant and resistivity of the material of the slab inserted in the capacitor are K = 1 and ρ respectively. The emf of the ideal cell is V. The current flowing through dielectric slab immediately after the key is switched on is



(A) $\frac{V}{\rho d}S$ (B) $\frac{2V}{\rho d}S$ (C) $\frac{V}{2\rho d}S$ (D) zero

6. A capacitor of 2μF can withstand a maximum potential difference of 5V. It is connected with another capacitor of 5μF. The series combination can now withstand a potential difference of 7V. The maximum voltage that 5μF can withstand is

(A) 1 volt (B) 2 volt

(C) more than or equal to 2 volt (D) less than or equal to 2V.

EXERCISE # O-2

1. Following operation can be performed on a capacitor :

X – connect the capacitor to a battery of emf E.

Y – disconnect the battery.

Z – reconnect the battery with polarity reversed.

W – insert a dielectric slab in the capacitor.

(A) In XYZ (perform X, then Y, then Z) the stored electric energy remains unchanged and no thermal energy is developed.

(B) The charge appearing on the capacitor is greater after the action XWY than after the action XYW.

(C) The electric energy stored in the capacitor is greater after the action WXY than after the action XYW.

(D) The electric field in the capacitor after the action XW is the same as that after WX.

2. A parallel plate capacitor with plate area A and separation d has charge Q. A slab of dielectric constant k is inserted in space between the plates almost completely fills the space. If E_0 and C_0 be the electric field and capacitance before inserting the slab, then

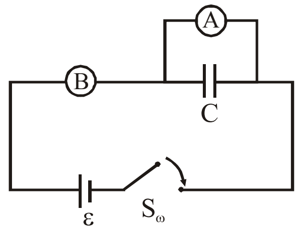
(A) the electric field after inserting the slab is $\frac{E_0}{k}$

(B) the capacitance after inserting the slab is $k\,C_0$

(C) the induced charge on the slab is $Q\left(1-\frac{1}{k}\right)$

(D) the energy stored in the capacitor becomes $\frac{U_0}{k}$, U_0 being the energy of the capacitor before inserting the slab

3. A capacitor of capacitance C is connected to two voltmeters A and B. A is an ideal voltmeter having infinite resistance, while B has resistance R. The capacitor is uncharged and then the switch S is closed at t = 0,



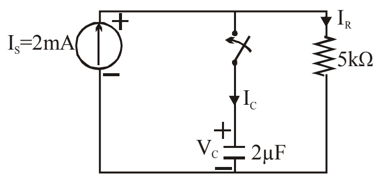
(A) Readings of B and A will be ε and zero at t = 0

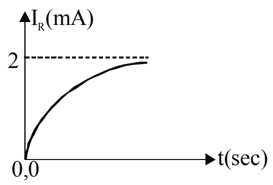
(B) During time interval $(0 \le t \le \infty)$ readings of B and A are changing

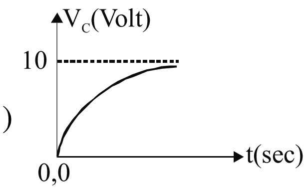
(C) Reading of A and B will be equal at t = RC ln 2

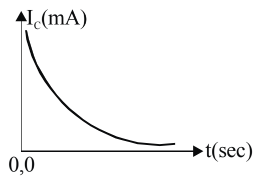
(D) None of these

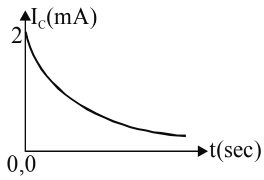
4. Consider a circuit with a constant current source of $I_S = 2mA$ with a capacitor of $2\mu F$ and resistor of $5k\Omega$ (as shown in figure). At t=0 the switch is closed. I_C & I_R denotes current in the capacitor & resistor branch respectively and V_C represents potential difference across the capacitor. Choose the correct graph(s).



(A)


(B)


(C)


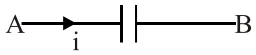
(D)


Paragraph for question nos. 5 to 7

5. Somewhere in a circuit is a resistor. A constant current is flowing in the direction as indicated in the figure. In going from A to B, we measure $\int_A^B \vec{E} \cdot d\vec{\ell}$. What do we find ?

(A) a positive value
(B) a negative value
(C) zero
(D) we do not have enough information to answer

6. Somewhere in a circuit is a parallel plate capacitor. A current is flowing in the direction as indicated in the figure, and this current is increasing. In going from A to B through the gap between the two plates of the capacitor, we again measure the integral as mentioned above. What do we find ?



(A) a positive value
(B) a negative value
(C) zero
(D) we do not have enough information to answer

7. Does it make any difference whether we go from A to B directly in a straight line or choose a random routing through free space starting at A and ending at B ?

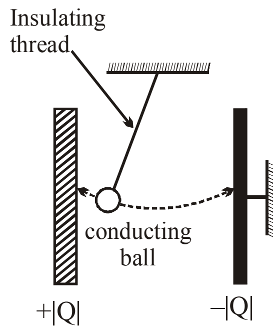
(A) no difference in case of resistor but difference in case of capacitors
(B) yes, there is a difference in case of resistor but no difference in case of capacitor
(C) no difference in case of resistor or capacitor.
(D) yes, there is a difference in case of resistor as well as capacitor

Paragraph for question nos. 8 to 10

Experiments with a charged capacitor

A capacitor and a Pendulum

We begin with an uncharged, isolated, parallel plate capacitor having its plates maintained at a fixed distance apart and with an isolated independent voltage source. By connecting the two plates of the uncharged capacitor momentarily to the independent voltage source and then disconnecting the source, we are left with a charged and isolated capacitor. A small ball of cork , covered with a conducting foil, is suspended by an insulating thread between the two plates of the capacitor as a simple pendulum. If the ball is initially at rest and is closer to the positive plate, it will be slightly attracted to that plate because of induction. On contact with the positive plate, some of the plate's positive charge is transferred to the ball by charge sharing. The positively charged ball then is repelled by the positive plate and attracted to the negative plate. Upon reaching the negative plate, the kinetic energy of the ball is completely converted into thermodynamic internal energy of the negative plate. The positive charge on the ball neutralizes some of the negative charge on the negative plate. The ball also then becomes negatively charged by charge sharing and subsequently is repelled by the negative plate and attracted back to the positive plate.



The process continues with the electric pendulum swinging back and forth between the two plates until essentially all of the charge on the capacitor is neutralized and the capacitor is discharged. We imagine positive charge transferred one way, negative charge the other way until the two plates are discharged. We observe that the force between the plates decreases with each swing of the pendulum, confirming our account of the neutralization or discharge of the two plates. Once discharged, the field between them is zero, they do not exert electric force on each other.

8. During the swinging of the charged ball

(A) the current is from left to right

(B) the current is from right to left

(C) the current is from left to right during when ball moves to the left and the current is from right to left when ball moves to the right

(D) the current is from right to left during when ball moves to the left and the current is from left to right when ball moves to the right.

9. Consider the moment when the ball leaves the positive plate taking away a charge of 0.01μC, leaving a charge of 8.85μC on the positive plate. The tension in the string, when the ball reaches the lowest position for the first time is nearly. (Assume the distance between the plates is 1cm and length of the thread is 1m, area of the plates is $1m^2$ and mass of ball is 1mg).

(A) 6×10^{-5} N (B) 3×10^{-5} N (C) 11×10^{-5} N (D) 10^{-5} N

10. If the initial charge on the capacitor plates is 10μC, and the capacitance of the capacitor is 10μF, the total change in thermodynamics internal energy of the left plate is :

(A) 5μJ (B) 2.5μJ (C) 10μJ (D) 7.5μJ

11. On a capacitor of capacitance C_0 following steps are performed in the order as given in column I.

(A) Capacitor is charged by connecting it across a battery of EMF V_0.

(B) Dielectric of dielectric constant k and thickness d is inserted

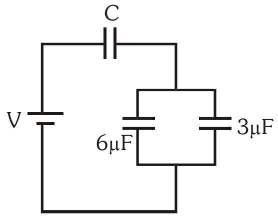
(C) Capacitor is disconnected from battery

(D) Separation between plates is doubled

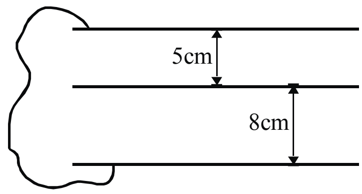
Column I	**Column II**
(Steps performed)	**Final value of Quantity (Symbols have usual meaning)**
(A) (a) (d) (c) (b)	(P) $Q = \frac{C_0V_0}{2}$
(B) (d) (a) (c) (b)	(Q) $Q = \frac{kC_0V_0}{k+1}$
(C) (b) (a) (c) (d)	(R) $C = \frac{kC_0}{k+1}$
(D) (a) (b) (d) (c)	(S) $V = \frac{V_0(k+1)}{2k}$

EXERCISE # S

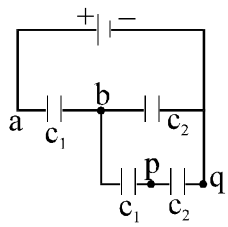
1. If charge on 3μF capacitor is 3μC. Find the charge on capacitor of capacitance C in μC. Here V = 10 V



2. Three conducting plates are placed parallel to one another as shown in the figure. The outer plates are neutral and connected by a conducting wire. The inner plate is isolated and carries a total charge amounting to 10 μC. The charge densities on upper and lower face of middle plate are σ_1 and σ_2. Find the value of $\frac{5\sigma_1}{\sigma_2}$.

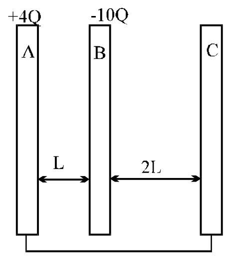


3. In the given network if potential difference between p and q is 2V and $C_2 = 3C_1$. Then find the potential difference between a & b.



4. A total charge 200 μC is imparted to identical parallel plate capacitors connected in parallel. At t = 0, the plates of the capacitor are 0.1 mm apart. The plates of first capacitor moves towards each other with approach velocity 0.001 m/s and plates of second capacitor move apart with same separation velocity. Find the current in the capacitors.

5. Three identical very large conducting plates, A, B & C are placed parallel to each other. Plates A & C are connected by thin conducting wire. A charge + 4Q is given to plate A & -10Q is given to plate B. Find the final charges on each surfaces of plates. Here separation between A & B is L, and between B & C is 2L.



6. A 10 μF and 20 μF capacitor are connected to a 10 V cell in parallel for some time after which the capacitors are disconnected from the cell and reconnected at t = 0 with each other , in series, through wires of finite resistance. The +ve plate of the first capacitor is connected to the –ve plate of the second capacitor. Draw the graph which best describes the charge on the +ve plate of the 20 μF capacitor with increasing time.

7. A capacitor of capacitance C_0 is charged to a potential V_0 and then isolated. A small capacitor C is then charged from C_0, discharged & charged again, the process being repeated n times. The potential of the large capacitor has now fallen to V. Find the capacitance of the small capacitor. If V_0 = 100 volt, V=35volt, find the value of n for C_0 = 0.2 μF & C = 0.01075 μF . Is it possible to remove charge on C_0 this way?

ANSWER KEY

EXERCISE # O-1

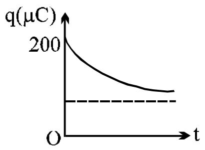
1. Ans. (B) 2. Ans. (B) 3. Ans. (B) 4. Ans. (B)
5. Ans. (A) 6. Ans. (C)

EXERCISE # O-2

1. Ans. (B, C, D) 2. Ans. (A, B, C, D) 3. Ans. (A, B, C) 4. Ans. (A, B, D)
5. Ans. (A) 6. Ans. (D) 7. Ans. (C) 8. Ans. (A)
9. Ans. (C) 10. Ans. (B)
11. Ans. (A) P, R, S; (B) P, R, S; (C) R; (D) Q, R]

EXERCISE # S

1. Ans. 9
2. Ans. 8
3. Ans. 30 V
4. Ans. 2 μA
5. Ans. –3Q, $\frac{+20Q}{3}, -\frac{20Q}{3}, \frac{-10Q}{3}, +\frac{10Q}{3}, -3Q$
6. Ans.



7. Ans. $C = C_0\left[\left(\frac{V_0}{V}\right)^{1/n} - 1\right] = 0.01078\ \mu F$, n = 20, No

EXERCISE # O-1

1. The resistance of a metallic conductor increases with temperature due to

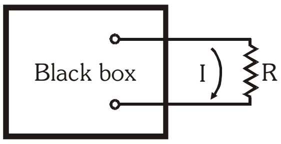
(A) Change in carrier density

(B) Change in the dimensions of the conductor

(C) increase in the number of collisions among the carriers

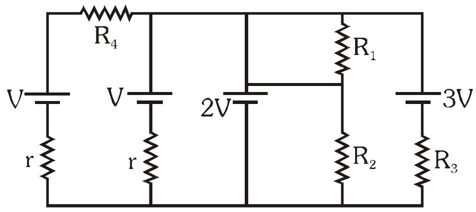
(D) increase in the rate of collisions between the carriers and the lattice.

2. In the given black box unknown emf sources and unknown resistance are connected by an unknown method such that (i) when terminals of 10 ohm resistance are connected to box then 1 ampere current flows and (ii) when 18 ohm resistance are connected then 0.6 A current flows then for what value of resistance does 0.1 A current flow?



(A) 118 Ω (B) 98 Ω (C) 18 Ω (D) 58 Ω

3. In the circuit shown, if $R_1 : R_2 : R_3 : R_4 = 1 : 2 : 3 : 4$ then



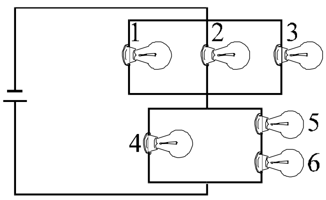
(A) Ratio of current in R_2 and R_3 is 3 : 1

(B) Ratio of current in R_1 and R_3 is 1 : 2

(C) Ratio of current in R_1 and R_2 is 4 : 5

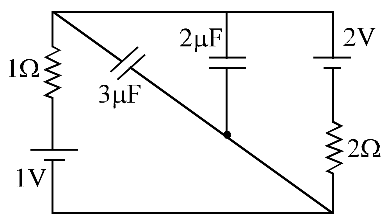
(D) current in R_1 is more than one in R_2

4. Six identical light bulbs are connected to a battery to form the circuit shown. Which light bulb(s) glow the brightest?



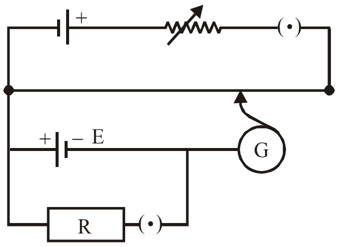
(A) 1, 2 and 3 (B) 5 and 6 (C) 1, 2, 3 and 4 (D) 4 only

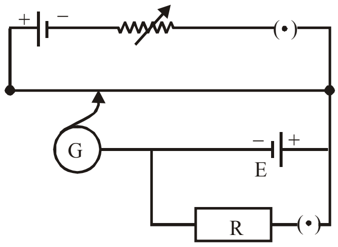
5. In the circuit shown, the charge on the 3μF capacitor at steady state will be

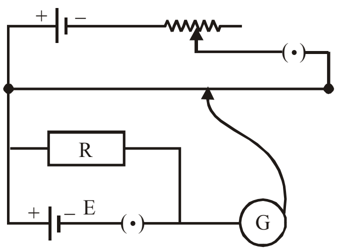


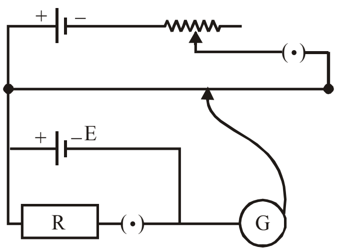
(A) 6 μC (B) 4 μC (C) 2/3 μC (D) 3 μC

6. The correct circuit for the determination of internal resistance of a battery by using potentiometer is:

(A) 

(B) 

(C) 

(D) 

7. In a meter bridge experiment, we try to obtain the null point at the middle. This

(A) reduces systematic error as well as random error.

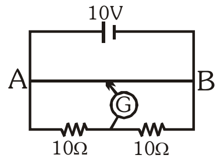
(B) reduces systematic error but not the random error.

(C) reduces random error but not the systematic error.

(D) reduces neither systematic error nor the random error.

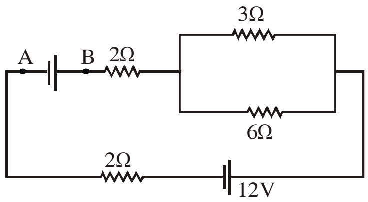
EXERCISE # O-2

1. The wire AB of a meter bridge changes linearly from radius r to 2r from left end to right end. Length of wire is 1m. Where should the free end of the galvanometer be connected on AB so that the deflection in the galvanometer is zero?



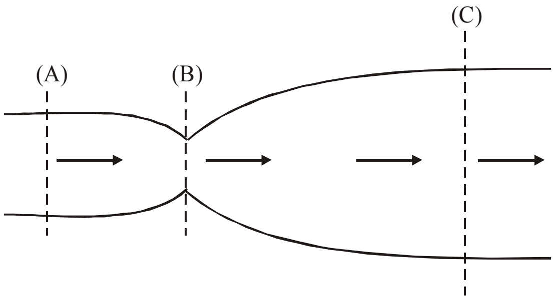
(A) $\frac{2}{3}$ m from end B (B) $\frac{1}{3}$ m from end A (C) $\frac{1}{4}$ m from end A (D) $\frac{3}{4}$ m from end B

2. The current through the 3Ω resistor (as shown in figure) is 2A. Then the value of $V_A - V_B$ will be



(A) 20 V (B) 6 V (C) –6V (D) – 20 V

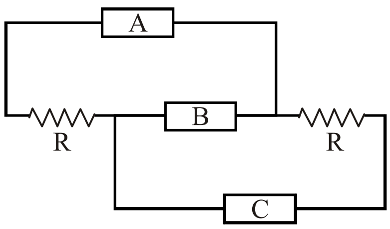
3. Figure shows a copper wire of nonuniform cross section carrying current toward right for sectors A, B and C.



(A) $i_B > i_A > i_C$ (i = current) (B) $E_B > E_A > E_C$ (E = electric field)
(C) $V_B > V_A > V_C$ (V = drift velocity) (D) $J_B > J_A > J_C$ (J = current density)

Paragraph for question nos. 4 to 6

A circuit is shown below.



4. If A is an ideal ammeter, B an ideal Battery of voltage V, and C an ideal voltmeter, what will be the $\frac{\text{reading of C}}{\text{reading of A}}$?

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

5. If A is a capacitor, B is an ideal ammeter and C is an ideal battery of voltage V, what is the voltage across the capacitor ?

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

6. If B is an inductor of inductance L, A an ideal battery of voltage V and C an ideal battery of voltage 2V each connected so that the anode is facing left, what is voltage across B as soon as the circuit is connected:

(A) $\frac{V}{2}$ (B) V (C) $\frac{3V}{2}$ (D) 0

Paragraph for Q. No. 7 to 9

An ammeter and a voltmeter are connected in series to a battery with an emf of 10V. When a certain resistance is connected in parallel with the voltmeter, the reading of the voltmeter decreases three times, whereas the reading of the ammeter increases the two times.

7. Find the voltmeter reading after the connection of the resistance.

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

8. If resistance of the ammeter is 2Ω, then resistance of the voltmeter is :–

(A) 1Ω (B) 2Ω (C) 3Ω (D) 4Ω

9. If resistance of the ammeter is 2Ω, then resistance of the resistor which is added in parallel to the voltmeter is :–

(A) $\frac{3}{5}\Omega$ (B) $\frac{2}{7}\Omega$ (C) $\frac{3}{7}\Omega$ (D) None of these

Paragraph for Q. No. 10 to 12

The major errors in the experiment to determine specific resistance of the material of a wire using meter bridge are due to the heating effect, end correction introduced due to shift of the zero of the scale at A and B, stray resistances in gaps of meter bridge and due to non-uniformity of wire.

10. The major errors mentioned above are

(A) systematic in nature (B) random in nature

(C) neither systematic nor random (D) both systematic & random

11. End correction α and β can be estimated by including known resistances R_1 and R_2 in the two gaps and finding the null point using equations

(A) $\frac{R_1}{R_2}=\frac{\ell_1-\alpha}{(100-\ell_1-\beta)},\frac{R_2}{R_1}=\frac{\ell_2-\alpha}{(100-\ell_2-\beta)}$ (B) $\frac{R_1}{R_2}=\frac{\ell_1+\alpha}{(100-\ell_1+\beta)},\frac{R_2}{R_1}=\frac{\ell_2+\alpha}{(100-\ell_2+\beta)}$

(C) $\frac{R_1}{R_2}=\frac{\ell_1-\alpha}{(100-\ell_1+\beta)},\frac{R_2}{R_1}=\frac{\ell_2+\alpha}{(100-\ell_2+\beta)}$ (D) $\frac{R_1}{R_2}=\frac{\ell_1+\alpha}{(100-\ell_1+\beta)},\frac{R_2}{R_1}=\frac{\ell_2-\alpha}{(100-\ell_2-\beta)}$

12. Error due to non-uniformity of meter bridge wire can be reduced by interchanging the resistances in the gaps of the meter bridge.

Error in specific resistance is given by $\frac{d\rho}{\rho}=\frac{dR}{R}+2\frac{dr}{r}+\frac{dL}{L}$. Here $\frac{dR}{R}$ depends on

(A) error in the measurement of resistance in R.B.

(B) error in the measurement of unknown resistance.

(C) error in the measurement of balancing length.

(D) All of the above.

Paragraph for question nos. 13 to 15

By varying the voltage applied to the kettle, you can change power consumption P. Depending on the P kettle with water can be heated to different maximum temperatures. This dependence is shown in

Table-1 :

Power P (in Watt)	**0**	**100**	**200**	**300**
Temperature T(in °C)	**20**	**40**	**60**	**80**

Table-2 shows the variation of the temperature with time when the kettle of power 300W is switched off.

The heat capacity of the empty kettle $C_0 = 100$ J/K, specific heat of water c = 4200 J/kg K, the density of water $\rho = 1000$ kg/m^3.

Table-2 :

Time t (in sec)	**0**	**60**	**300**	**600**	**1200**	**2400**
Temperature T (in °C)	**80**	**75**	**60**	**45**	**30**	**20**

13. If the power consumption is 400W

(A) The water will come to the boiling point and start boiling

(B) The water will reach boiling point but will not boil

(C) The water will not reach boiling point but start boiling

(D) The water will neither reach boiling point nor start boiling.

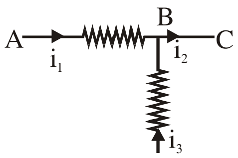
14. The rate of heat loss at t = 600 sec after the heater is switched off (as in table-2) is.

(A) 100 W (B) 125 W (C) 150 W (D) 200 W

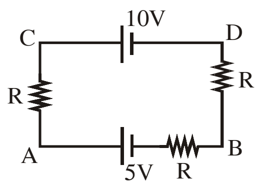
15. How many litres of water is present in the kettle?

(A) 1 litre (B) 0.6 litre (C) 0.4 litre (D) 0.8 litre

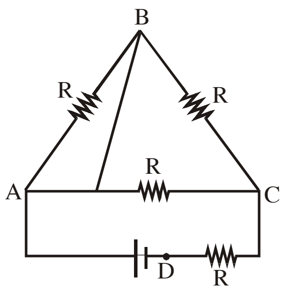
16. **Column I** **Column II**

(A) 

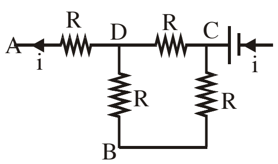
(P) $V_A > V_B$

(B) 

(Q) $V_B > V_C$

(C) 

(R) $V_C > V_D$

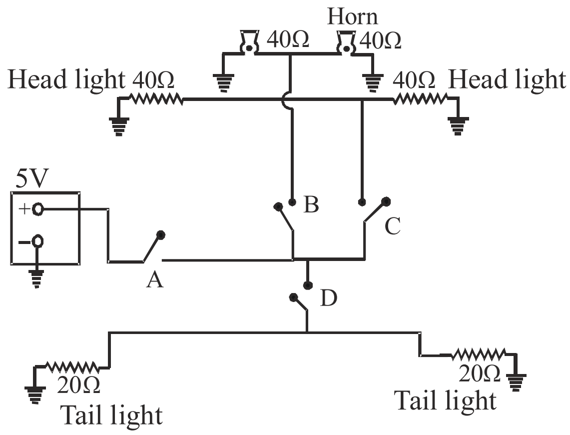
(D) 

(S) $V_A > V_D$

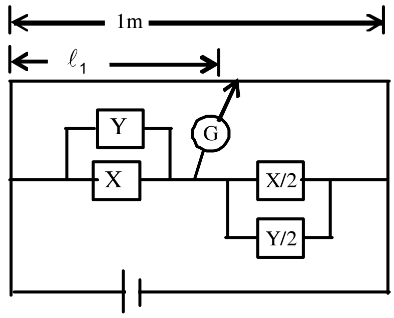
(T) $V_C - V_B > V_D - V_C$

EXERCISE # S

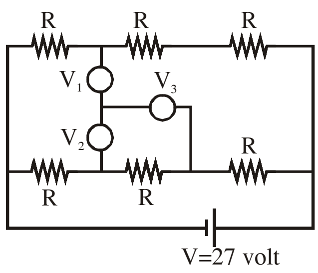
1. Figure shows an automobile circuit. How much power (in watt) is dissipated by the automobile circuit when switches A, B, C and D are all closed.



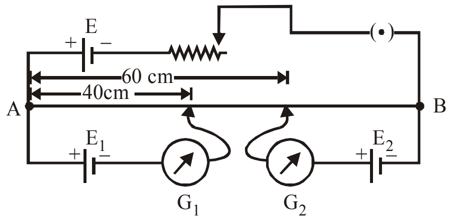
2. Figure shows a meter bridge. If there is no current through galvanometer then ℓ_1 is equal to $\frac{100N}{3}$ cm. Find the value of N.



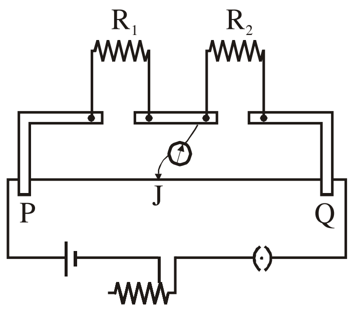
3. In the circuit shown below, all the voltmeter identical and have very high resistance. Each resistor has the same resistance. The voltage of the ideal battery shown is 27 V. Find the reading of voltmeter V_3 (in volts).



4. Consider the following circuit where AB is a one meter long potentiometer wire. If both galvanometers G_1 and G_2 show null deflection, then find the value of $3\times\frac{E_1}{E_2}$.



5. The circuit diagram given in the figure shows the experimental setup for the measurement of unknown resistance by using a meter bridge. The wire connected between the points P & Q (PQ = 100 cm) has uniform cross-sectional area and its resistivity is directly proportional to the distance from point P. Null point is obtained with the jockey J with R_1 and R_2 in the given position. On interchanging the positions R_1 and R_2 in the gaps the jockey has to be displaced through a distance Δ from the previous position along the wire to establish the null point. If the ratio of $R_1/R_2=3$, find the value of Δ(in cm). Ignore any end corrections. [Take $\sqrt{3}$ = 1.7]



ANSWER KEY

EXERCISE # O-1

1. Ans. (D)	**2. Ans. (A)**	**3. Ans. (A)**	**4. Ans. (D)**	**5. Ans. (B)**
6. Ans. (D)	**7. Ans. (A)**			

EXERCISE # O-2

1. Ans. (A,B)	**2. Ans. (B,D)**	**3. Ans. (B,C,D)**	**4. Ans. (A)**	**5. Ans. (D)**
6. Ans. (C)	**7. Ans. (B)**	**8. Ans. (C)**	**9. Ans. (A)**	**10. Ans. (A)**
11. Ans. (B)	**12. Ans. (C)**	**13. Ans. (B)**	**14. Ans. (B)**	**15. Ans. (D)**

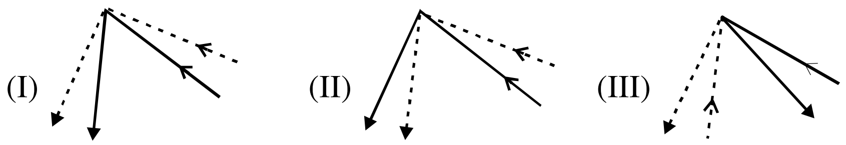
16. Ans. (A) →(P); (B) →(P,R,S,T); (C) →(Q,R,S,T); (D) →(R,T)

EXERCISE # S

1. Ans. 5	**2. Ans. 2**	**3. Ans. 6**	**4. Ans. 3**	**5. Ans. 35**

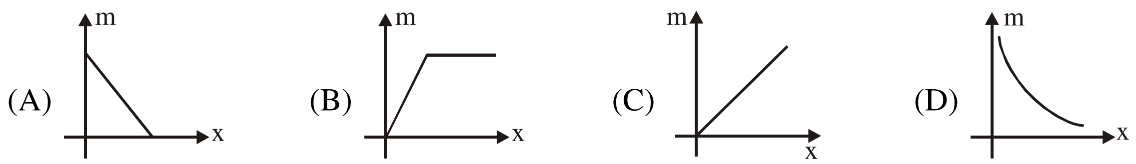
EXERCISE # O-1

1. Each of these diagrams is supposed to show two different rays being reflected from the same point on the same mirror. Which option is correct.



(A) Only I (B) Only II (C) Only III (D) All

2. Which of the following graphs is the magnification of a real image against the distance of object from the focus of a concave mirror?



3. **Statement-1**: You see a geostationary satellite above the horizon. You desire to communicate with the satellite by sending a beam of laser light. You should aim your laser slightly higher than the line of sight of the satellite.

Statement-2: Light bends away from the normal while moving from denser to rarer medium.

(A) Statement-1 is true, statement-2 is true and statement-2 is correct explanation for statement-1.

(B) Statement-1 is true, statement-2 is true and statement-2 is NOT the correct explanation for statement-1.

(C) Statement-1 is true, statement-2 is false.

(D) Statement-1 is false, statement-2 is true.

4. A medium bounded by the planes x = 0, x = a, y = b, y = –b, z = c and z = 0 has refractive index $\mu(x, z) = Az^3 - Bx + 2$. A ray of light travelling along positive z-axis enters the medium at point $P\left(\frac{1}{B}, 0\right)$, then the optical path introduced by the medium (where the light ray emerges out) will be

(A) $\frac{Ac^4}{4}$ (B) $4Ac^4$ (C) 2c (D) $\frac{Ba^2}{2}$

5. As light from the sun enters the atmosphere, it refracts due to the small difference between the speeds of light in air and in vacuum. The optical length of the day is defined as the time interval between the instant when the top of the sun is just visibly observed above the horizon to the instant at which the top of the sun just disappears below the horizon. The geometric length of the day is defined as the time interval between the instant when a geometric straight line drawn from the observer to the top of the sun just clears the horizon to the instant at which this line just dips below the horizon?

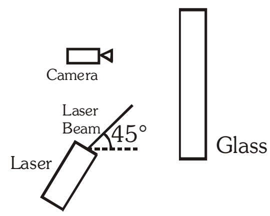
(A) The optical length of a day is longer than geometrical length.

(B) The geometric length of the day is longer than optical length

(C) Optical length and geometrical length of day are equal.

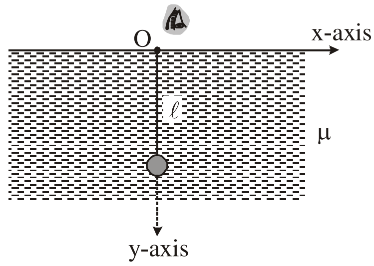
(D) Cannot be determined.

6. A quality control engineer working at the Davinci Glass Company has invented a new method to measure the thickness of glass panes. By directing a laser beam at an incident angle of 45° w.r.t. the glass, he notices that not one but two parallel beams are reflected. He measures the distance between the reflected beams with an automated camera system, as shown. (The camera is pointed directly at the reflected beams). Assuming that the index of refraction of glass is $\sqrt{2}$, and the distance between the reflected beams is measured to be 1 mm, how thick is the glass ?



(A) $\frac{1}{\sqrt{6}}$ mm (B) $\sqrt{\frac{2}{3}}$ mm (C) $\sqrt{\frac{3}{2}}$ mm (D) None of these

7. A pendulum of length ℓ is free to oscillate in vertical plane about point O in a medium of refractive index μ. An observer in air is viewing the bob of the pendulum directly from above. The pendulum is performing small oscillations about its equilibrium position. The equation of trajectory of bob as seen by observer is:

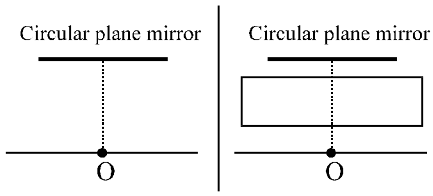


(A) $x^2 + y^2 = \ell^2$ (B) $\frac{x^2}{(\ell/\mu)^2} + \frac{y^2}{\ell^2} = 1$ (C) $\frac{x^2}{\ell^2} + \frac{y^2}{(\ell/\mu)^2} = 1$ (D) $x^2 + y^2 = \left(\frac{\ell}{\mu}\right)^2$

8. An isosceles glass prism having refractive index μ has one of its faces coated with silver. A ray of light is incident normally on the other face (which is equal to the silvered face). The ray of light is reflected twice on the same sized faces and then emerges through the base of the prism perpendicularly. The angles of prism are

(A) 40°, 70°, 70° (B) 50°, 65°, 65° (C) 36°, 72°, 72° (D) data insufficient

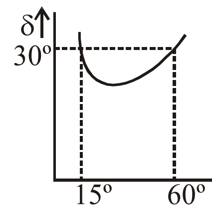
9. In the diagram shown below, a point source O is placed vertically below the center of a circular plane mirror. The light rays starting from the source are reflected from the mirror such that a circular area A on the ground receives light. Now, a glass slab is placed between the mirror and the source O. What will the magnitude of the new area on the ground receiving light?



(A) A (B) Greater than A (C) Less than A

(D) Cannot tell, as the information given is insufficient

10. Figure shows graph of deviation δ versus angle of incidence for a light ray striking a prism. Angle of prism is



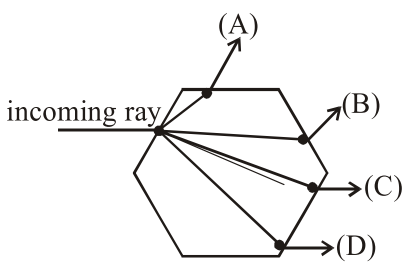
(A) 30º

(B) 45º

(C) 60º

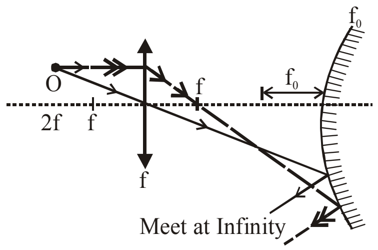
(D) 75º

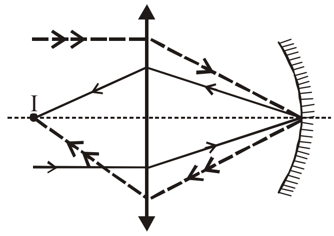
11. A light ray strikes a hexagonal ice crystal floating in the air as shown in the figure. The correct path of ray may be ?

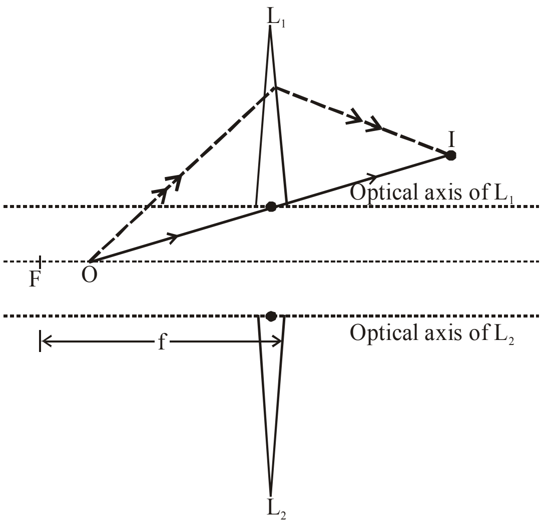


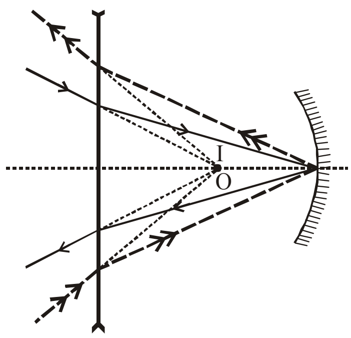
12. Choose the incorrect ray diagram. All the rays shown are paraxial.

[denotes converging lens and denotes diverging lens]

(A) 

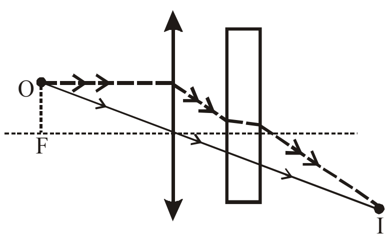
(B) 

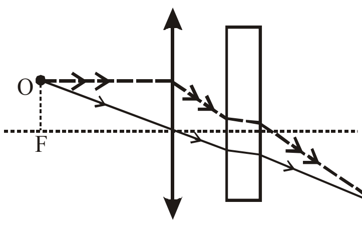
(C) 

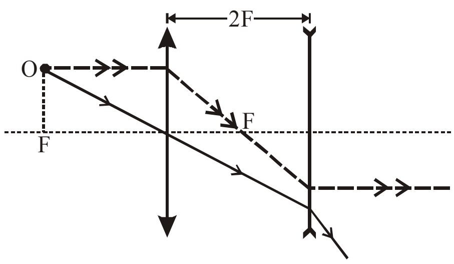
(D) 

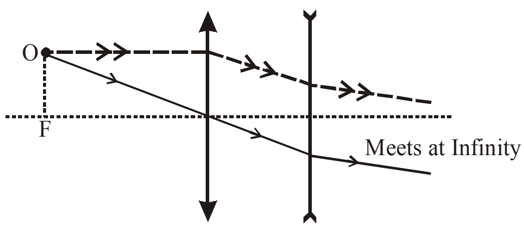
13. Choose incorrect ray diagram [denotes converging lens and denotes diverging lens]

All symbols have their usual meaning and all the rays shown are paraxial. (focal length of each lens is F)

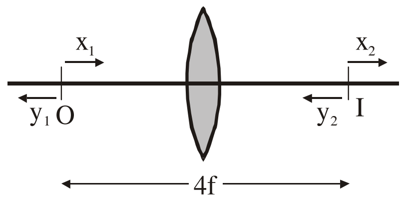
(A) 

(B) 

(C) 

(D) 

14. In a converging lens of focal length f and the distance between real object and its real image is $4f$. If the object moves x_1 distance towards lens its image moves x_2 distance away from the lens and when object moves y_1 distance away from the lens its image moves y_2 distance towards the lens, then choose the correct option :-



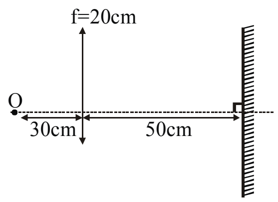
(A) $x_1 > x_2$ and $y_1 > y_2$ (B) $x_1 < x_2$ and $y_1 < y_2$

(C) $x_1 < x_2$ and $y_1 > y_2$ (D) $x_1 > x_2$ and $y_2 > y_1$

15. A point object is located 30 cm in front of a camera lens of aperture diameter 6 cm. The image is focussed on the film plate. If the film plate is moved back 10 cm the width of the image blurs to 1 cm wide. Find the focal length of the lens.

(A) 20 cm (B) 10 cm (C) 30 cm (D) 40 cm

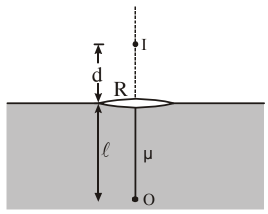
16. In the given situation object and plane mirror are fixed while the lens is performing SHM perpendicular to principle axis with an amplitude 4mm. At mean position of the lens the object lies on the principal axis. Distance between two extreme positions of image formed by mirror is (consider paraxial light rays)



(A) 1.2 cm (B) 2.4 cm (C) 0.8 cm

(D) can not be determined with the given information

17. Equi-biconvex lens forms image I of the object O as shown in figure. The radius of curvature of the lens is R and its refractive index is 2μ, the refractive index of liquid below the lens is μ. If the liquid level is raised so that the lens just gets completely sub merged, then the position of the final image shift by



(A) $d\left(1-\frac{1}{\mu}\right)$ (B) $d\left(1-\frac{1}{2\mu}\right)$ (C) $\frac{R}{\mu}$ (D) $\frac{R}{2\mu}$

18. It is desired to make an achromatic combination of two lenses (L_1 & L_2) made of materials having dispersive powers ω_1 and ω_2 ($<\omega_1$). If the combination of lenses is converging then

(A) L_1 is converging

(B) L_2 is converging

(C) Power of L_1 is greater than the power of L_2

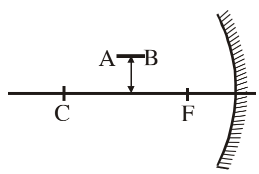
(D) None of these

19. Consider a common mirage formed by super-heated air just above a roadway. A truck driver is in a medium of μ = 1.000 3 looks forward. He perceives the illusion of a patch of water ahead on the road, where his line of sight makes an angle of 1.20° below the horizontal. Find the index of refraction of the air just above the road surface. (*Hint:* Treat this as a problem in total internal reflection.)

(A) 1.00006 (B) 1.0001 (C) 1.00008 (D) None of these

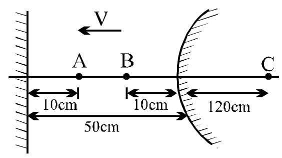
EXERCISE # O-2

1. An object AB is placed parallel and close to the optical axis between focus F and centre of curvature C of a converging mirror of focal length f as shown in figure.



(A) Image of A will be closer than that of B from the mirror.
(B) Image of AB will be parallel to the optical axis.
(C) Length of image is equal to AB.
(D) Length of image is more than AB.

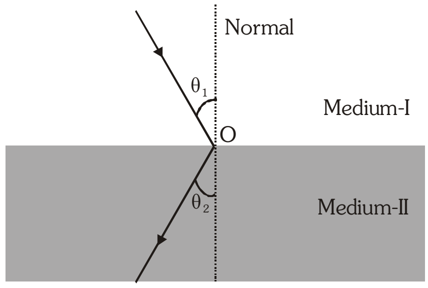
2. In the figure shown consider the first reflection at the plane mirror and second at the convex mirror. AB is object.



(A) the second image is real , inverted of $1/5^{th}$ magnification w.r.t AB
(B) the second image is virtual and erect with magnification 1/5 w.r.t AB
(C) the second image moves towards the convex mirror
(D) the second image moves away from the convex mirror.

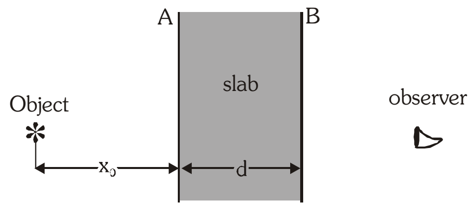
Paragraph for Question Nos. 3 & 4

If Snell's law is found valid for two media, whose refractive indexes have opposite signs, the incident and the refracted rays must lay on the same side of the normal at the point of incidence. In the figure is shown a ray crossing the interface between two media makes angle θ_1 and θ_2 with the normal in medium–I and medium–II of refractive indexes μ_1 and μ_2. Refractive indexed of these media 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 equation $\mu_1\sin\theta_1=\mu_2\sin\theta_2$, the angles θ_1 and θ_2 must also have opposite signs.

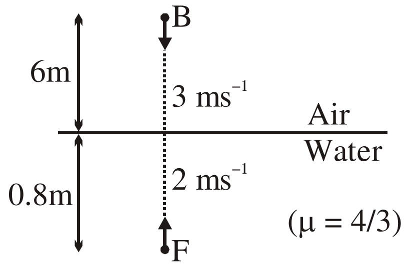
3. A self–luminous point object placed at distance x_0 from a slab of transparent material of negative refractive index is viewed through it as shown in the figure. Thickness of the slab is d, refractive index of material of the slab with respect to the outside medium is $\mu = -1$. For different magnitudes of value of x_0 and d the observer may find real or virtual image of the object. Which of the following statement is true? Do not use any sign conventions.



(A) If $x_0 > d$ image is virtual and for $x_0 < d$ image is real.
(B) If $x_0 < d$ image is virtual and for $x_0 > d$ image is real.
(C) If $x_0 \leq d$ image is virtual and for $x_0 > d$ image is real.
(D) If $x_0 > d$ image is virtual and for $x_0 \leq d$ image is real.

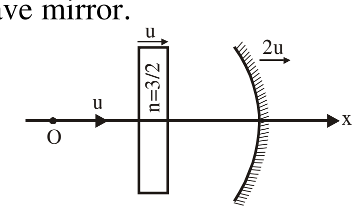
4. Suppose a virtual object is placed instead of a real object at a distance x_0 from the surface A of the slab. Now which of the following statement is true? Do not use any sign conventions.
(A) If $x_0 < d$ a real image is formed outside the slab and for, $x_0 > d$ a virtual image is formed inside the slab.
(B) If $x_0 < d$ a real image is formed and for $x_0 > d$ a virtual image is formed and in both the case the image is outside the slab.
(C) For both the cases $x_0 < d$ and $x_0 > d$ a real and erect image is formed outside the slab.
(D) For both the cases $x_0 < d$ and $x_0 > d$ a real and inverted image is formed outside the slab.

5. A fish, F in the pond, is at a depth of 0.8 m from water surface and is moving vertically upwards with velocity 2 ms^{-1}. At the same instant, a bird B is at a height of 6 m from water surface and is moving downwards with velocity 3 ms^{-1}. At this instant both are on the same vertical lines as shown in the figure. Which of the following statement(s) is(are) correct?



(A) Height of B, observed by F (from itself) is equal to 8.00 m.
(B) Depth of F, observed by B (from itself) is equal to 6.60 m.
(C) Velocity of B, observed by F (relative to itself) is equal to 5.00 ms^{-1}.
(D) Velocity of F, observed by B (relative to itself) if equal to 4.50 ms^{-1}.

6. For the system as shown in the figure, the image formed by the concave mirror.



(A) will have speed greater than the speed of the object.
(B) will move in the direction of motion of the mirror.
(C) will have speed greater than the speed of the mirror.
(D) moves away from the mirror.

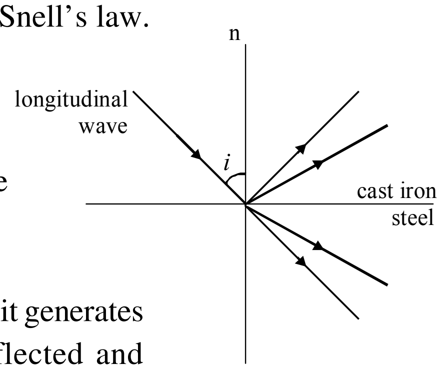
Paragraph for Question Nos. 7 to 9

When a wave reaches at boundary of any medium it get partially refracted and partially reflected. Direction of refracted as well as reflected ray can be given by Snell's law.

$$\frac{\sin i}{v_i} = \frac{\sin r}{v_r}$$

v_i = velocity of incident wave

v_r = velocity of reflected/refracted wave



For the reflected wave of same type, $v_i = v_r$ as the wave returns to the same medium. Thus sin i = sin r $\Rightarrow$ i = r.

It is observed that when a longitudinal wave reaches at a surface, it generates longitudinal and transverse wave. These two waves get reflected and transmitted in direction suggested by Snell's law.

Given that
velocity of longitudinal wave in steel = 4000 m/s
velocity of longitudinal wave in cast iron = 3000 m/s
velocity of transverse wave in steel = 3200 m/s
velocity of transverse wave in cast iron = 1600 m/s

Longitudinal waves come at boundary of cast iron and steel from cast iron at angle of incidence i.

7. If the longitudinal wave is incident at an angle of 30°, then the angle between the refracted longitudinal and reflected transverse wave will be :-

(A) $\sin^{-1}\frac{2}{3} - \sin^{-1}\frac{4}{15}$
(B) $\sin^{-1}\frac{2}{3} + \sin^{-1}\frac{4}{15}$
(C) $\pi - \sin^{-1}\frac{2}{3} - \sin^{-1}\frac{4}{15}$
(D) $\frac{5\pi}{6} - \sin^{-1}\frac{2}{3}$

8. If the angle of incidence of longitudinal wave is such that produced longitudinal wave just fails to enter steel, then the angle of reflection for transverse wave will be :-

(A) $\sin^{-1}\frac{3}{4}$
(B) $\sin^{-1}\frac{2}{5}$
(C) $\sin^{-1}\frac{4}{5}$
(D) $\frac{\pi}{2}$

9. Choose the **CORRECT** statement :-

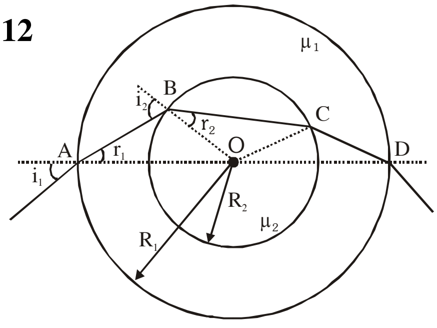
(A) For any angle of incidence, we can never get transverse wave in steel.

(B) Reflected longitudinal wave will be closer to normal than reflected transverse wave (normal is taken towards cast iron)

(C) Refracted transverse wave will bend towards the normal.

(D) Refracted longitudinal wave will bend away from the normal.

Paragraph for Question Nos. 10 & 12



There is a spherical glass ball of refractive index μ_1 and another glass ball of refractive index μ_2 inside it as shown in figure. The radius of the outer ball is R_1 and that of inner ball is R_2. A ray is incident on the outer surface of the ball at an angle i_1.

10. Find the value of r_1

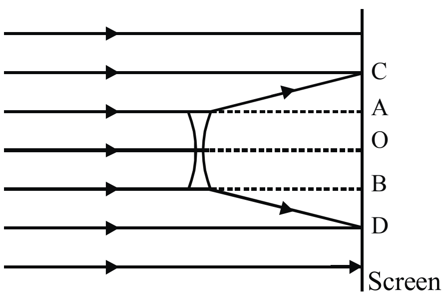
(A) $\sin^{-1}\left(\frac{\sin i_1}{\mu_1}\right)$ (B) $\sin^{-1}(\mu_1 \sin i_1)$ (C) $\sin^{-1}\left(\frac{\mu_1}{\sin i_1}\right)$ (D) $\sin^{-1}\left(\frac{1}{\mu_1 \sin i_1}\right)$

11. Find the value of r_2

(A) $\sin^{-1}\left(\frac{R_1}{\mu_2 R_2}\sin i_1\right)$ (B) $\sin^{-1}\left(\frac{R_2}{\mu_2 R_1}\sin i_1\right)$

(C) $\sin^{-1}\left(\frac{R_1}{\mu_1 R_2}\frac{1}{\sin i_1}\right)$ (D) $\sin^{-1}\left(\frac{R_2}{\mu_1 R_1}\sin i_1\right)$

12. A concave lens is placed in the path of a uniform parallel beam of light falling on a screen as shown. Then



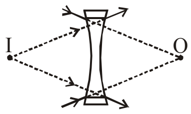
(A) intensity of light will be the uniform everywhere on the screen.

(B) intensity in the region AB will be lesser than what it would be in the absence of the lens.

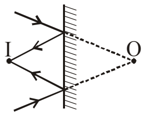
(C) in the region AC and BD, the intensity will be lesser than what it would be in the absence of the lens.

(D) in the region AC and BD, the intensity will be more than what it would be in the absence of the lens.

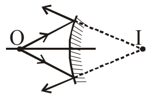
13. The nature of object and image given with each of the optical condition is shown. Choose the **correct** option(s)

(A) Virtual image 

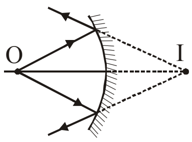
Virtual object

(B) Virtual image 

Real object

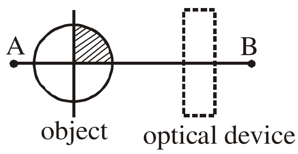
(C) Real object 

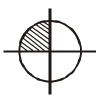
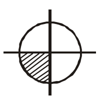
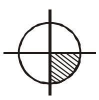
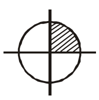
Virtual image

(D) Real object 

Virtual image

14. A very small circular object is kept in front of an optical device as shown in figure. The plane of object is parallel to the optical device. Match the images as seen by the observer (ignoring magnification)



Column-I (Probable image)	**Column-II (Device)**
(A) 	(P) Plane mirror (The observer is at A)
(B) 	(Q) Concave mirror (The observer is at A)
(C) 	(R) Convex mirror (The observer is at A)
(D) 	(S) Convex lens (The observer is at B)
	(T) Concave lens (The observer is at B)

15. Medium of lens in (R), (S), (T) is denser than surroundings **:-**

Column I

(A) real erect image cannot be formed

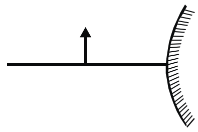
(B) virtual erect image cannot be formed

(C) real inverted image cannot be formed

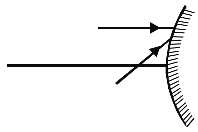
(D) virtual inverted image cannot be formed

Column II

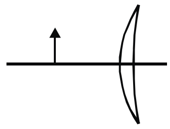
(P) object placed in front of a convex mirror



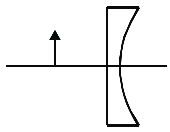
(Q) converging beam incident on a convex mirror



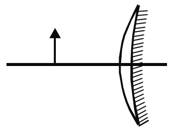
(R) Object placed in front of a lens having the shape as shown



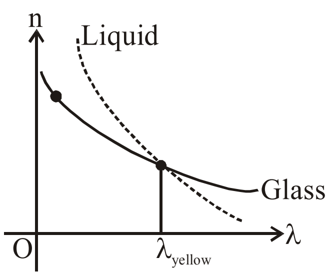
(S) Object placed in front of a lens having the shape as shown

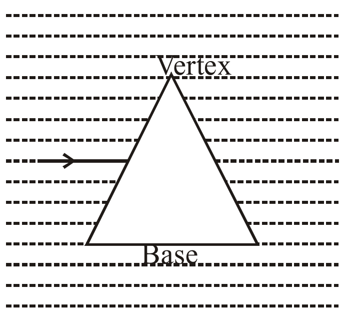


(T) Object placed in front of a silvered lens as shown.



16. A glass prism is immersed in a hypothetical liquid. The curves showing the refractive index n as a function of wavelength λ for glass and liquid are as shown in the figure. When a ray of white light is incident on the prism parallel to the base :





(A) yellow ray travels without deviation

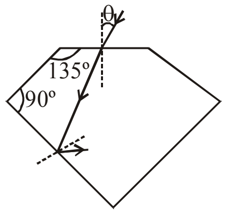
(B) blue ray is deviated towards the vertex

(C) red ray is deviated towards the base

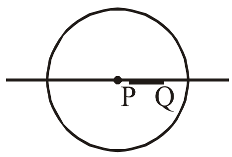
(D) there is no dispersion

EXERCISE # S

1. A ray of light enters a diamond (n = 2) from air and is being internally reflected near the bottom as shown in the figure. Find maximum value of angle θ possible ?

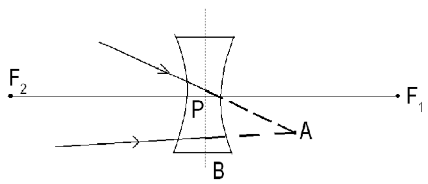


2. A small object of length 1 mm lies along the principal axis of a spherical glass of radius R = 10 cm and refractive index is 3/2. The object is seen from air along the principal axis from left. The distance of object from the centre is 5 cm. Find the size of the image. Is real, inverted ?

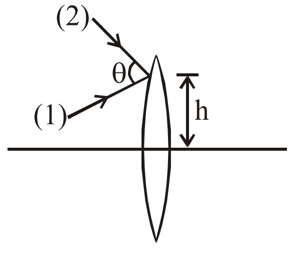


3. A lens is placed at origin, with x-axis as its principal axis. A ray of light is incident on it from the –ve side of x-axis along the line $y = \frac{x}{400} + 0.1$, where x, y are in cm. Focal length of lens is 30 cm. Find the equation of the ray after passing through the lens.

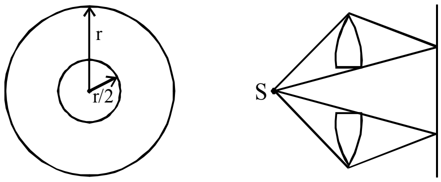
4. The rays of a converging beam meet at a point A. A diverging lens is placed in their path in the plane B. Plot the position of the point where the rays meet after passing through the lens. The position of the principal foci FF is known.



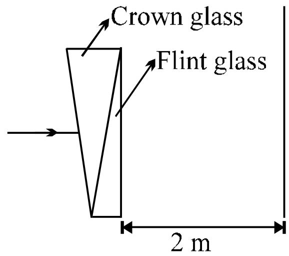
5. Find deviation suffered by ray (1) as it emerges from the lens of focal length f. Also find the angle between the two rays after they emerge from the lens. Both rays are paraxial.



6. There is a hole in middle of a thin converging lens whose radius is $\frac{1}{2}$ × radius of the lens. The lens has a focal length of 4 cm. A point object is kept 9 cm from a screen and this lens is kept in between. It is seen that there is a single circular illuminated spot on the wall with a sharp edge (as seen in figure). What is the distance of the lens from the object (in cm) ? Consider the case when the rays after refraction from the lens are converging in nature.



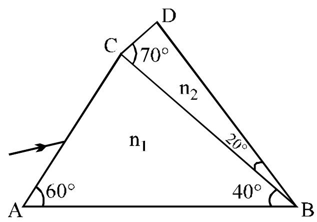
7. The refractive indices of the crown glass for violet and red lights are 1.51 and 1.49 respectively and those of the flint glass are 1.77 and 1.73 respectively. A prism of angle 6° is made of crown glass. A beam of white light is incident at a small angle on this prism. The other thin flint glass prism is combined with the crown glass prism such that the net mean deviation is 1.5° anticlockwise.



(i) Determine the angle of the flint glass prism.

(ii) A screen is placed normal to the emerging beam at a distance of 2m from the prism combination. Find the distance between red and violet spot on the screen. Which is the topmost colour on screen.

8. A prism of refractive index n_1 & another prism of refractive index n_2 are stuck together without a gap as shown in the figure. The angles of the prisms are as shown . n_1 & n_2 depend on λ, the wavelength of light according to $n_1 = 1.20 + \frac{10.8\times10^4}{\lambda^2}$ &



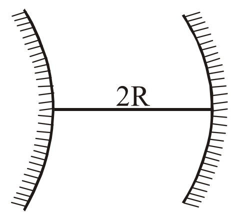
$n_2 = 1.45 + \frac{1.80\times10^4}{\lambda^2}$

where λ is in nm.

(i) Calculate the wavelength λ_0 for which rays incident at any angle on the interface BC pass through without bending at that interface.

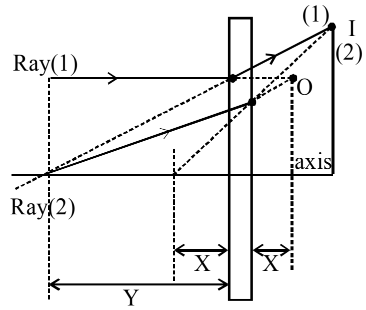
(ii) For light of wavelength λ_0, find the angle of incidence i on the face AC such that the deviation produced by the combination of prisms is minimum.

9. Two spherical mirrors, one convex and the other concave, each of same radius of curvature R are arranged coaxially at a distance of 2R from each other as shown in figure. A small circle of radius a is drawn on the convex mirror. What is the radii of first three images of the circle.



10. If light passes near a massive object, the gravitational interaction causes a bending of the ray. This can be thought of as happening due to a change in the effective refractive index of the medium given by $n(r) = 1 + 2\, GM/rc^2$ where r is the distance of the point of consideration from the centre of the mass of the massive body, G is the universal gravitational constant, M the mass of the body and c the speed of light in vacuum. Considering a spherical object find the deviation of the ray from the original path as it grazes the object.

11. The rectangular box shown is the place of lens. By looking at the ray diagram, answer the following questions :



(i) If X is 5 cm then what is the focal length of the lens ?

(ii) If the point O is 1 cm above the axis then what is the position of the image ? Consider the optical center of the lens to be the origin.

ANSWER KEY

EXERCISE # O-1

1. Ans. (A)	2. Ans. (D)	3. Ans. (D)	4. Ans. (A)
5. Ans. (A)	6. Ans. (C)	7. Ans. (C)	8. Ans. (C)
9. Ans. (A)	10. Ans. (B)	11. Ans. (A)	12. Ans. (A)
13. Ans. (A)	14. Ans. (C)	15. Ans. (A)	16. Ans. (B)
17. Ans. (A)	18. Ans. (B)	19. Ans. (C)	

EXERCISE # O-2

1. Ans. (A,D)	2. Ans. (B,C)	3. Ans. (D)	4. Ans. (C)
5. Ans. (B,D)	6. Ans. (A,B,C)	7. Ans. (C)	8. Ans. (B)
9. Ans. (D)	10. Ans. (A)	11. Ans. (A)	12. Ans. (B,D)

13. Ans. (A,C,D) **14. Ans. (A) – (P,Q,R) ; (B) – (Q) ; (C) – (S) ; (D) – (S,T)**

15. Ans. (A) – (P,R,S,T) ; (B) – (Q) ; (C) – (P,Q,S,T) ; (D) – (P,R,S,T)

16. Ans. (A,B,C)

EXERCISE # S

1. Ans. $\theta < \sin^{-1}(2\sin 15°)$ **2. Ans.** $\left(\frac{16}{25}\text{mm}\right)$

3. Ans. $y = -\frac{x}{1200} + 0.1$ **4. Ans.** Real, below principal axis, anywhere b/w P & F_1]

5. Ans. $\delta_1 = \tan^{-1}\left(\frac{h}{f} - \tan\frac{\theta}{2}\right) + \frac{\theta}{2}$ $\delta_2 = \tan^{-1}\left(\frac{h}{f} + \tan\frac{\theta}{2}\right) - \frac{\theta}{2}$

& Angle between rays = $\tan^{-1}\left(\frac{h}{f} + \tan\frac{\theta}{2}\right) - \tan^{-1}\left(\frac{h}{f} - \tan\frac{\theta}{2}\right)$

6. Ans. d = 6 cm **7. Ans.** (i) 2°, (ii) $\frac{4\pi}{9}$ mm

8. Ans. (i) λ_0 = 600 nm, n = 1.5 (ii) i = $\sin^{-1}(0.75)$ = 48.59°

9. Ans. $r_1 = \frac{a}{3}$, $r_2 = \frac{a}{11}$, $r_3 = \frac{a}{50}$ **10. Ans.** $\frac{4GM}{Rc^2}$

11. (i) f = – 10 cm, (ii) (10, 2)