PLUS MODEL EXAMINATION:2021 (PHYSICS)
QUESTION & ANSWER KEY

1	**The name of the wave associated with matter is ....** **Ans. de – Broglie wave.**	1
2	**The vertical plane passing through the axis of rotation of earth is called ......** **Ans. Geographic meridian.**	1
3	**What happens to the ray of light when it travels from rarer to denser medium?** **a. bends toward the normal. b. Bends away from the normal.** **c. no change.** **Ans. bends toward the normal.**	1
4	**Which physical quantity is quantised in Bohr's second postulate?** **Ans. Angular momentum.**	1
5	**Infrared spectrum lies between** **a. radio and microwave b. Visible and UV** **c. microwave and visible d. UV and X Rays** **Ans.c. microwave and visible.**	1
6	**How many electrons constitute 1 coulomb of charge.($e=1.6x10^{-19}C$)** **Ans. $6.25x10^{18}$ [*Explanation:* $n = Q/e = 1/1.6x10^{-19}$]**	1
7	**When a ray of light enters a glass slab from air:** **a. its wavelength decreases. b. Its wavelength increases.** **c. its frequency increases. d. its frequency decreases.** **Ans. a. its wavelength decreases.** ***[Explanation: $v = f\lambda$ Or $\lambda = v/f$*** ***When light enters to glass, its speed decreases and hence its wavelength also decreases.]***	1
8	**Name the series of hydrogen spectrum which has least wavelength?** **Ans. Lyman series.**	1
9	**a. Define electric potential.** **b.Give the relation between electric intensity and electric potential.** **Ans.a. Electric potential at a point is the work done in moving a unit positive charge from infinity to that point against the electrostatic force.** **b. E = -dV/dr**	2

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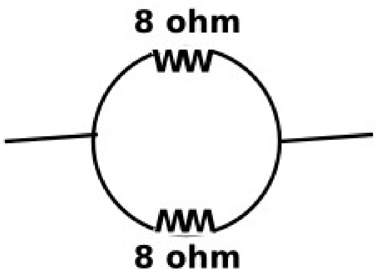
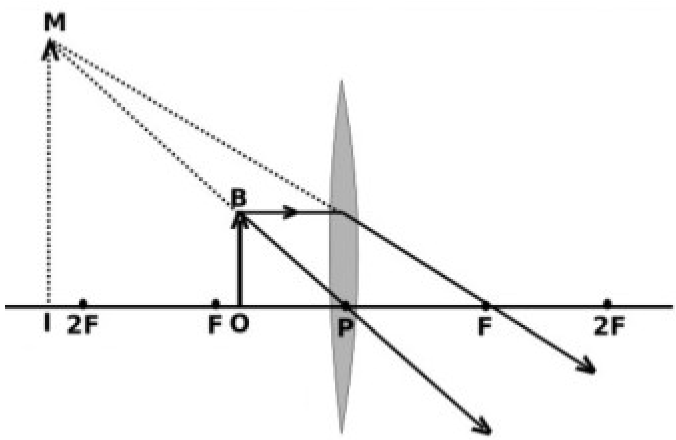
10	**a. What is the principle of potentiometer?** **b. Write one practical application of Wheatstone's bridge.** **Ans.a.When a constant current flows through a wire of uniform thickness, the potential drop across any length of the wire is directly proportional to that length.** **b. Meter bridge.**	**2**
11	**A wire has a resistance of 16 Ω. It is bent in the form of a circle. Find the effective resistance between two points on any diameter.** **Ans. $R= R_1.R_2/(R_1+R_2)$ =8x8/18 = 4 Ω** ***[Explanation: Each half will have 8Ω resistance and these can be considered to be connected in parallel as shown.]*** 	**2**
12	**a.A stationary charge can produce magnetic field (True/False).** **b. Write down the equation for magnetic Lorentz force.** **Ans.a. false. [*Stationery charge produces electric field*]** **F= q(vxB) = qvBSinθ**	**2**
13	**a.What is the intensity of magnetisation of magnetic materials?** **b. Give the relation between B & H.** **Ans.a. Intensity of magnetisation (M)is the magnetic moment developed per unit volume of a material when placed in a magnetising field.** **b. B = μH.**	**2**
14	**State Faraday's Laws of Electromagnetic induction?** **Ans.i. Whenever the magnetic flux linked with a conductor is changed an emf is induced in the conductor.** **ii. The magnitude of induced emf is equal to the rate of change of magnetic flux linked with the conductor.**	**2**
15	**Draw the ray diagram for a convex lens producing virtual image.** **Ans.** 	**2**

16 State any two postulates of Bohr atom model. **2**

Ans.i. The electrons are permitted to those orbits in which the angular momentum is an integral multiple of h/2π.

ii. Energy is absorbed or released when electrons are transferred from one stationery orbit to another.

17 a. State the law of radio active decay. **2**

b.What are the number of protons and neutrons in a nucleus $_{92}U^{238}$

Ans.a. The law states that the number of nuclei disintegrating per second of a radio active sample at any instant is directly proportional to the number of undecayed nuclei present in the sample at that instant.

b. Number protons = 92   Number neutrons = 238-92 = 146

18 In the magnetic meridian of certain place, the horizontal component of earth's magnetic field is 0.26 G and the dip angle is 60°. What is the magnetic field of earth at this location? **2**

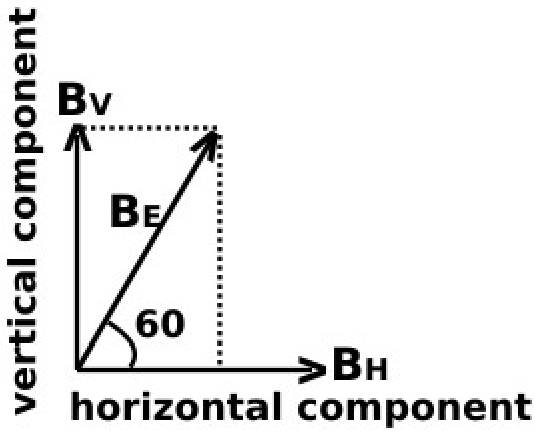
Ans. B_H = 0.26 G   Dip, θ = 60°

From the figure,

Cos 60 = B_H/B_E

Or Earth's field B_E

= B_H/Cos60 = 0.26/cos60=0.52G



19 a. Give the principle of a transformer. **2**

b. Give the two energy losses in transformer.

Ans.a. Mutual induction.

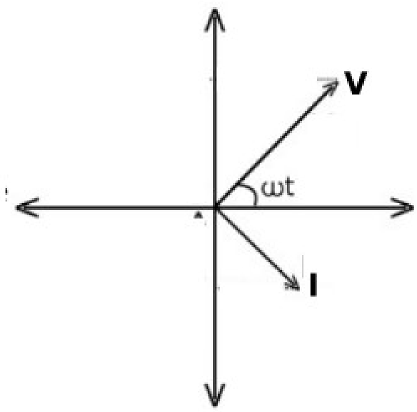
b. Energy losses due to Eddy current, flux leakage, Joule's heating effect.

20 a. Draw the phasor diagram with V & I for an inductive circuit. **2**

b. What is the phase difference between V & I in an inductive circuit?

Ans.a.

b. 90°



21 Give two differences between nuclear fission and nuclear fusion. **2**

Ans.i. Nuclear fission is a quick process. But Nuclear fusion occurs in several steps having sufficient time gap between initial and final steps.

ii. Nuclear fission produces very harmful radio active wastes. But the products of fusion are harmless.

22 a.What is meant by forbidden energy gap? **2**

b. Write any one use of Zener diode.

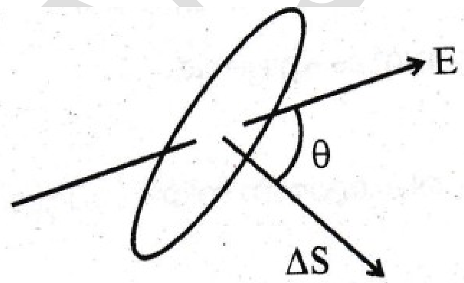
Ans.a. The energy gap between valence band and conduction band is called forbidden energy gap.

b. Zener diode is used as voltage regulator.

23 a.State Gauss's theorem. **3**

b. Give the equation for electric flux through a given surface when the angle between electric field and area is 45°.

c.What is the flux through the surface if the surface is parallel to the field of lines?



Ans.a. It states that total electric flux through any closed surface is equal to $(1/\varepsilon_0)$ times the net charge enclosed by the surface.

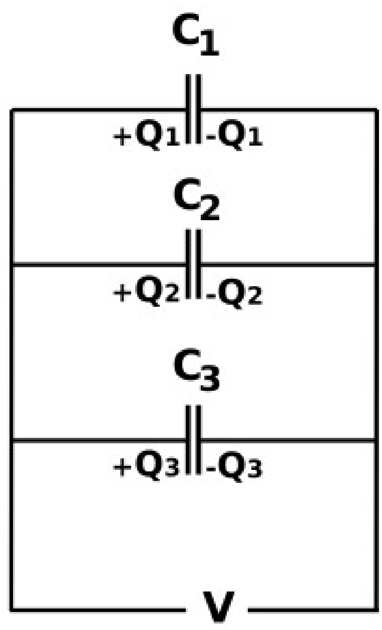
That is, $\Phi = \int E.dS = q/\varepsilon_0$

b. $\Phi = E.S.\cos\theta = E.S.\cos 45 = ES/\sqrt{2}$

c. $\Phi = E.S.\cos 90 = 0$

24 Find the effective capacitance when three capacitors are connected in parallel. **3**

Ans. Let C_1, C_2 and C_3 are two capacitors connected as in fig.



Let the charges on each capacitors are Q_1, Q_2 and Q_3

Total charge $Q = Q_1 + Q_2 + Q_3$ …..(1)

But $Q_1 = C_1V$, $Q_2 = C_2V$ and $Q_3 = C_3V$

Substitute these in Eqn.(1):

$Q = C_1V + C_2V + C_3V$ …… (2)

If the three capacitors are replaced by a single capacitor with effective capacitance C.

Then Eqn.(2) becomes, $CV = C_1V + C_2V + C_3V$

Or $C = C_1 + C_2 + C_3$

25 A solenoid of 0.5 m length has radius 1 cm and is made up of 500 turns. It carries a current of 5 A. What is the magnitude of magnetic field inside the solenoid? **3**

Ans. $B = \mu_0 nI$

Here $n = N/L = 500/0.5 = 1000$ & $I = 5A$

Then $B = 4\pi \times 10^{-7} \times 1000 \times 5 = 6.28 \times 10^{-3}$ T

26	**a.Name the angle between horizontal component of Earth's magnetic field and earth's magnetic field?** **b. Define two magnetic elements of the earth.** **Ans.a. Dip.** **b.i.Dip: It is the angle that the total magnetic field B_E of the earth makes with the surface of the earth.** **ii. Declination: Declination is the angle between geographic meridian and magnetic meridian.**	**3**

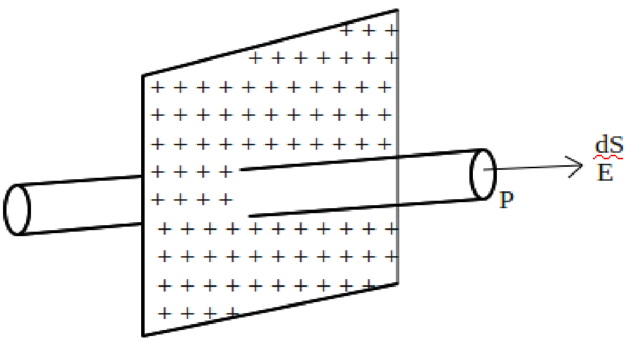
27	**a.Name the principle of AC Generator.** **b. Derive the equation for instantaneous emf in an AC Generator.** **Ans. a. Electromagnetic induction.** **b. Let the coil rotated with uniform angular velocity ω. At any instant t, let the normal to the plane of the coil make an angle θ with the direction of magnetic field B.** **Total magnetic flux linked with the coil at the instant t,** $\Phi = NBA\cos\theta = NBA\cos\omega t$ **(Since $\omega = \theta/t$)** **where N total number of turns, 'A'- area of the armature coil.** **According to Faraday's law of electromagnetic induction, induced emf is given by** $e = -d\Phi/dt = -d/dt(NBA\cos\omega t)$ $= -NBA(-\sin\omega t) \times \omega = NBA\omega \sin\omega t = e_0 \sin\omega t$ **Where** $e_0 = NBA\omega$	**3**

28	**a.Give two properties of electromagnetic waves.** **b. Give one use of radio waves.** **Ans.a. They do not need any material medium for propagation.** **ii. All electromagnetic waves can travel at a speed of 3×10^8 m/s through vacuum.** **b. It is used in radio and Television communication.**	**3**

29	**State Brewster's Law. A glass plate of refractive index 1.60 is used as a polariser. Find the polarising angle.** **Ans.i.It states that the tangent of polarizing angle (p) is equal to the refractive index of the medium.** **ii. We have** $\tan p = n$ **Then polarising angle** $p = \tan^{-1}(n) = \tan^{-1}(1.6) = 58°$	**3**

30	**Calculate the work function in electron volt for a metal.Given that the photoelectric threshold wavelength is 6800A°** **Ans. We have work function** $\varphi_0 = h\upsilon_0 = hc/\lambda_0$ $= 6.626\times10^{-34} \times 3\times10^{8}/6800\times10^{-10} = 2.92\times10^{-19}$ J $= 2.92\times10^{-19}/1.6\times10^{-19} = 1.83$eV	**3**

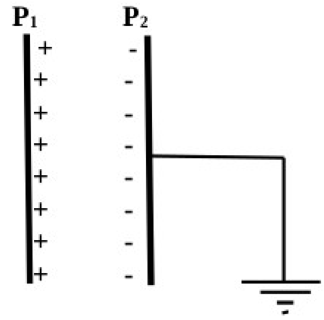
31	**Derive an equation for electric field intensity due to an infinite thin sheet of charge using Gauss's Law.** **Ans. Consider a uniformly charged infinite plane sheet with surface charge density σ C/m².** **Let P be a point at a distance 'r' from the sheet and E be the electric field there. Consider a small circular area dS around P with its plane parallel to the sheet. With this area as one of the end faces, imagine a Gaussian cylindrical surface having length 2r passing through the sheet.**	**3**



Since curved surface of this Gaussian surface is parallel to the field, no flux is passed through its curved surface. So flux passes only through the two end faces.
Total flux passes through Gaussian surface Φ =EdS+EdS= 2EdS
Net charge enclosed by the Gaussian cylinder = σ dS
According to Gauss theorem, 2EdS = $(1/\varepsilon_0)(\sigma\, dS)$
Therefore E = $\sigma/2\varepsilon_0$

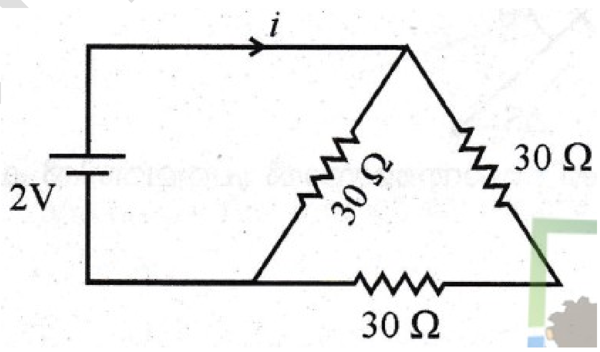
32 **Derive the equation for the capacitance of a parallel plate capacitor.** **3**

Ans. A parallel plate capacitor consists two parallel conducting plates P_1&P_2 separated by a small distance d.
Let the plate P_1 is given a charge +Q. Then a charge –Q will be induced on P_2.
If 'A' be the area of the plates, then surface charge density on each plate is σ = Q/A

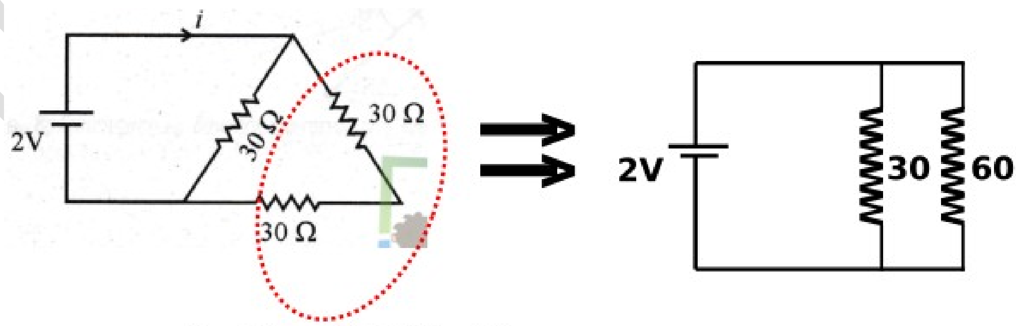


The field between the plates,
$E = \sigma/2\varepsilon_0 + \sigma/2\varepsilon_0 = \sigma/\varepsilon_0$ But σ = Q/A
Then $E = Q/\varepsilon_0 A$.
This field is uniform through out the region and is directed from positive to negative plate.
Potential difference between these plates
$V = E.d = (Q/\varepsilon_0 A).d = Qd/\varepsilon_0 A$ … (1)
Capacitance of a capacitor, $C = Q/V = Q/(Qd/\varepsilon_0 A) = \varepsilon_0 A/d$
If the space between the plates is filled with a medium of dielectric constant K, $C = \varepsilon_0 KA/d$.

33 **Find the value of current 'i' in the circuit shown in the figure.** **3**



Ans. Effective resistance
R= 30x60/(30+60)=20
Current = V/R = 2/20 = 0.1A



R1+R2=30+30=60

34 *a.State ampere's circuital law.* **3**

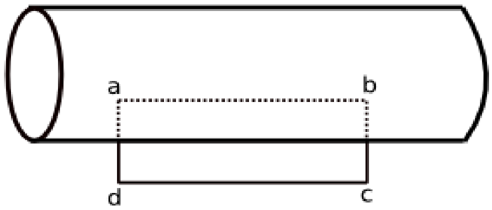
b.Find the magnetic field along the axis of a solenoid at its centre carrying current.

Ans.a. The line integral of magnetic field (B) around any closed path in free space is equal to μ_0 (permeability of free space) times the total current enclosed by the path.

b.Consider a long solenoid carrying current I as shown in fig.

Let 'n' be the number of turns per unit length.

Let 'B' be the magnetic field inside the solenoid. Consider a rectangular loop abcd (Amperian loop) as shown. As the section 'cd' of the loop is outside the solenoid, there is no magnetic field along cd. Similarly there is no field component along 'bc' & 'ad' as they are perpendicular to the field.



Total number of turns inside the loop = n.h (take 'ab' = h)

Then total current enclosed in the loop, I_e = I(n.h)

According to Ampere's circuital theorem,

$B.cd + B.da + B.cb + B.ab = \mu_0$ (total current enclosed)

Or $0+0+0+B.h = \mu_0 I(n.h)$ Or $B = \mu_0 nI$

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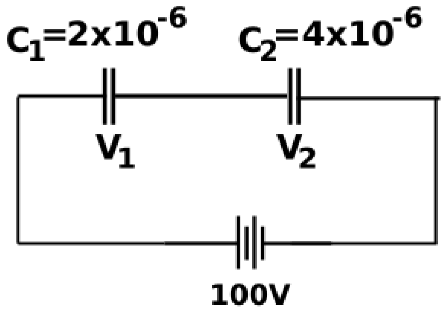
35 **a. Give SI unit of capacitance.** **4**

b. Two capacitors of capacitance 2μF and 4μF are connected in series to a potential difference of 100V. Calculate the potential difference across each capacitor.

Ans.a. farad.

Let V_1 and V_2 be potential difference and Q be charge stored on each capacitors.



$V_1 = Q/C_1 = Q/2x10^{-6}$ ..... (a)

$V_2 = Q/C_2 = Q/4x10^{-6}$ ...... (b)

(a)/(b):- $V_1/V_2 = 4/2 = 2$ .... (c)

But we have $V_1 + V_2 = 100$ ..... (d)

Using equations (c)&(d), V_1= 66.7V & V_2 = 33.3V

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36 **Derive an equation for the magnetic field due to a circular loop carrying current, at any point on the axis using Biot – Savart's law.** **4**

Ans. Consider a circular coil of radius R carrying current I as shown. 'P' is a point on the axis of the coil at a distance x from the centre of the coil. Consider a small element 'dℓ' of the loop as shown in fig.

Let r be the distance from this element to the point P.

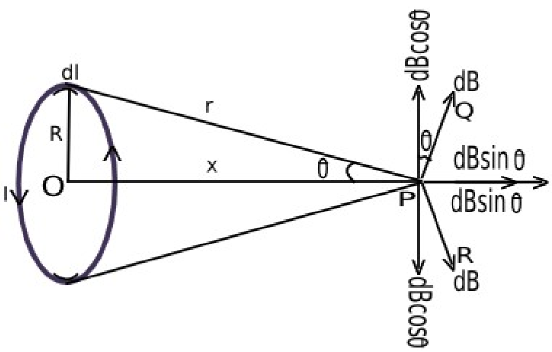
The magnetic field at P due to this element,$dB = (\mu_0/4\pi)\, Id\ell \sin 90/r^2$

$= (\mu_0/4\pi).Id\ell/r^2$, which is perpendicular to the plane containing dℓ and r (along PQ).

Consider a similar element from the diametrically opposite side of the coil .

The magnetic field at P due to this element is same as that of the first element. But the direction is along PR.

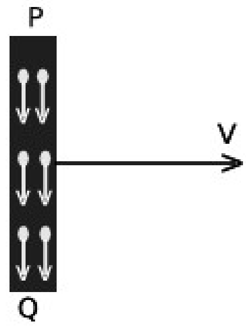
Now the fields dBs are resolved into two mutually perpendicular components as dBsinθ and dBcosθ. The dBcosθ components are equal and opposite and hence they cancel each other.



But the dBsinθ components are along the axis of the loop along the direction OP.
The total field at P due to the entire loop will be obtained by integrating dBsinθ
Therefore $B = \int dB\sin\theta = \int(\mu_0/4\pi).Id\ell/r^2.R/r$ (Since $\sin\theta = R/r$)
$= (\mu_0/4\pi)IR/r^3 \int d\ell = (\mu_0/4\pi)IR/r^3 .2\pi R$ (Since $\int d\ell = 2\pi R$, perimeter of the loop)
$= (\mu_0/2).IR^2/r^3$
From the figure, we have, $r = (R^2 + x^2)^{1/2}$, then $B = \mu_0 IR^2/2(R^2 + x^2)^{3/2}$

37 a.What is motional emf? **4**
b. Derive the equation for the induced emf between the ends of a straight conductor moving perpendicular to the magnetic field.

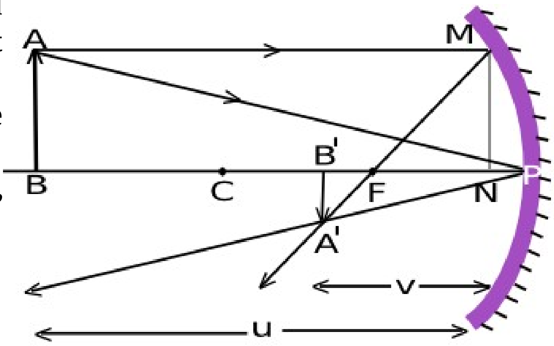
Ans.a. The emf induced across the ends of a conductor due to its motion in a magnetic field is called motional emf.



b. Consider a straight conductor of length 'ℓ' moving with a velocity v perpendicular to a uniform magnetic field B. The direction of B is normally into the plane of the paper.
Now the free electrons in the conductor experience Magnetic Lorentz force,
$F=q(v\times B)=qvB.\sin 90 = qvB$, where q is charge of free electrons.
The direction of this force will be along PQ as in fig.
Due to this force, the free electrons shifts from the end P to the end Q.
This will produce an electric field E inside the conductor. Due to this field, the free electrons experience electrical force qE and hence the electrons begin to flow from from Q to P
The flow of electrons continuous till the two forces balance each other.
Then $qE = qvB$ Or $E = vB$ …….(1)
If 'e' is the motional emf in the conductor, $E = e/\ell$ ….(2)
From (1) & (2), motional emf, $e = Bvl$

38 Derive mirror formula for a concave mirror. **4**

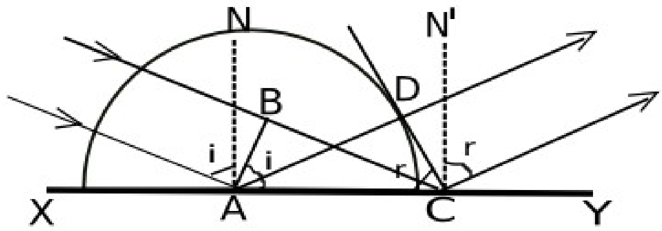
Ans. An object AB is placed before a concave mirror. A ray AM which is emanating from point A of the object incident at M and reflected back through the principal focus of the mirror. Another ray AP incidents at the pole P and reflected obeying law of reflection. The two reflected rays meet at A^1 . Then image A^1B^1 is formed there.



Let 'u' be the object distance, 'v' the image distance and 'f' be the focal length.
Consider the right angled triangles A^1B^1F & MNF, which are similar triangles.
Then $B^1A^1/NM = B^1F/FN$ …….. (a)
For paraxial rays, point P and N are very nearer and hence FN= FP
Then Eqn.(a) becomes $B^1A^1/AB = B^1F/FP$ ……….. (b)
Consider another pair of right angled triangles ABP and A^1B^1P
Since $\angle APB = \angle A^1PB^1$, these triangles are also similar triangles.
Therefore $B^1A^1/AB = B^1P/BP$ ……..(c)
Comparing (b) & (c), $B^1F/FP = B^1P/BP$ ……..(d)
But $B^1F=(B^1P – FP)$
Then Eqn.(d) becomes, $(B^1P – FP)/FP = B^1P/BP$ ……. (e)
Here B^1P is the image distance v, PF is the focal length f and BP is the object distance u.
By applying sign conventions,we get $PB^1=-v$, $PF=-f$ and $PB = -u$.
Then Equation (e) becomes, $(-v+f)/-f = -v/-u$
Or $(v-f)/f = v/u$ Or $1/f = 1/v + 1/u$
This is known as mirror formula.

39 | **4**

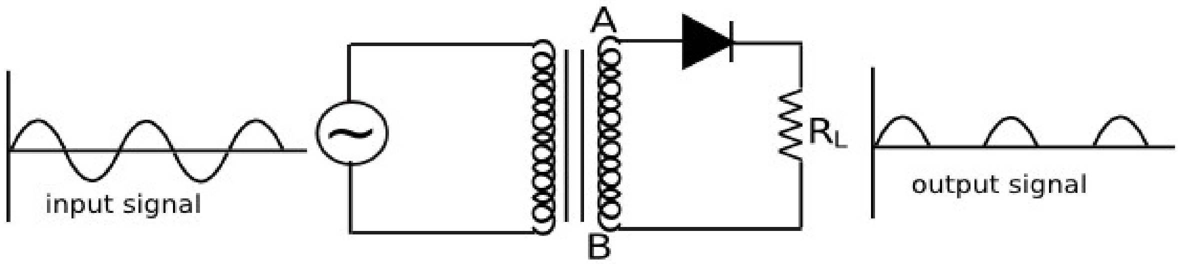
a.State Huygen's principle.
b. Based on Huygen's wave theory of ight,show that angle of incidence is equal to angle of reflection.
Ans.a. According to Huygen's principle, each point on a wavefront is a source of secondary waves, which add up to give a wavefront at any later time.
b. Consider a reflecting surface XY. AB represents a section of plane wavefront incident on the reflecting surface at an angle i.
At time t= 0, the point A on the incident wavefront reached the reflecting surface. After a time t,the ray from B reach at the point C on the reflecting surface.



t = BC/c, where c - velocity of light in free space.
When light reaches from B to C, secondary wavelets from A will spread on a sphere of radius AD = BC.
Draw a circle with 'A' as centre and radius AD. The tangent CD drawn on the circle will give reflected wave front and AD give the reflected ray.
Consider Δ[s]ABC & ADC.
Since the sides AC = AC , AD = BC and <ABC = <ADC = 90˚,the triangles are congruent.
So the corresponding angles <BAC and <ACD are equal.
That is, angle of incidence i = angle of reflection r.

40 | **4**

a.What is the use of a rectifier?
b. With the help of a neat diagram, explain how a diode acts as a rectifier.
Ans.a. Rectifier is a device which converts AC to DC.
b. A diode is included in a circuit as in figure. The output of a transformer supplies the voltage

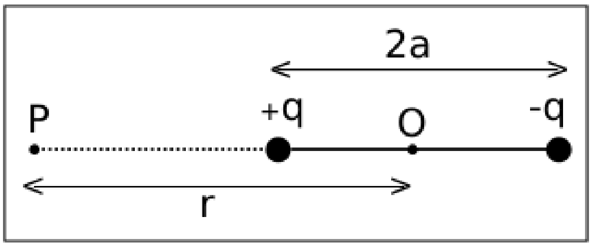


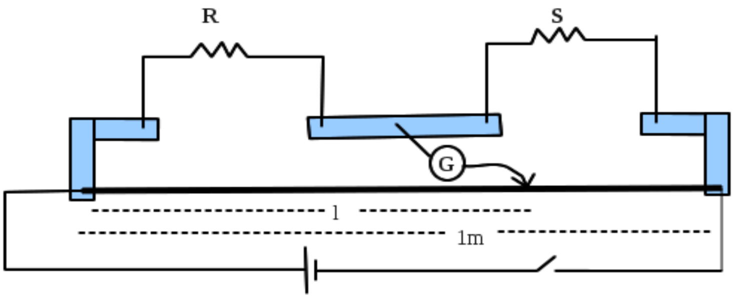
HALF WAVE RECTIFIER

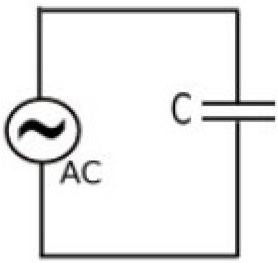
across the terminals A&B. During first half cycle of ac, let the terminal A is at positive potential and B at negative potential. Now the diode is forward biased and conduct this half of the pulse and it passes through the load R_L.
During the next half, the terminal 'A' becomes negative and 'B' positive. Now the diode is reverse biased and hence this half will be blocked. But the next half will conduct and so on. Then the output voltage through the load is as in fig. That is, all negative half pulses are being blocked and passing only positive halves. Therefore the output current is unidirectional.

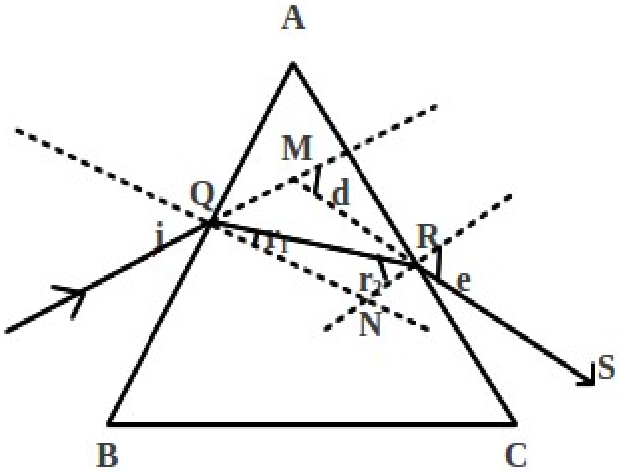
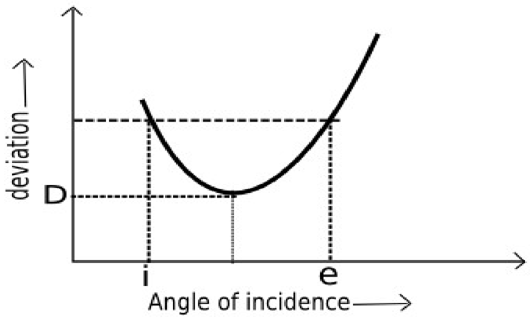
41 | **4**

a. Define the principal focus of a convex lens.
b. Write the phenomenon related to the image formation in a lens.
c. A convex lens of focal length 10 cm is combined with a concave lens of focal length 15 cm. Find the focal length of the combination.
Ans.a. A narrow beam of light parallel to the principal axis converges to point on the principal axis after refraction through a convex lens. This point is called principal focus of convex lens.
b. Refraction.
c. f_1 = 10 cm f_2 = -15 cm $F = f_1 x f_2/(f_1+f_2)$ = 10x-15/(10+-15)=-150/-5=-30 cm

42	**What is dipole moment. Derive the equation for the electric field intensity on the axial line of a dipole.** **Ans. Dipole moment of an electric dipole is a vector whose magnitude is the product of one of the charges and separation between the charges.** **Consider an electric dipole of charges +q and –q and length '2a' as in fig.** **Let O be the mid point of the dipole.** **Let P be a point on the axis at a distance r from O.** **Field at P due to +q is ,** **$E_{+q} = (1/4\pi\varepsilon_0)\times q/(r-a)^2$ along OP** **Field at P due to –q is,** **$E_{-q} = (1/4\pi\ \varepsilon_0)\times q/(r+a)^2$ along PO** **The total field at P,** **$E = E_{+q} - E_{-q} = (q/4\pi\varepsilon_0)\,[1/(r-a)^2 - 1/(r+a)^2]$** **$= (q/4\pi\varepsilon_0)[(r+a)^2-(r-a)^2] \div (r^2-a^2)^2$** **$= (q/4\pi\varepsilon_0)[4ar] \div (r^2-a^2)^2$** **$=(1/4\pi\varepsilon_0)4qa/r^3$ (since r>>a,neglect a^2)** **$= (1/4\pi\ \varepsilon_0)\ 2P/r^3$ (Since 2qa = P)**  	5

43	**Explain with the help of a neat diagram, how metre bridge is used to find the unknown resistance of a wire.** **Ans. Let R is an unknown resistance, whose resistance is to be measured.** **For this, insert a standard resistance S in one the gaps of the Meter Bridge as shown. Then move the jockey from left end along the wire and observe the galvanometer reading. When the reading is zero, the balancing length ℓ is measured. If R_{cm} is the resistance of the wire per cm, the resistance of ℓ cm wire is $R_{cm}.\ell$ and the resistance of remaining wire is $(100-\ell)R_{cm}$**  **According to Wheatstone's bridge principle, $R/S = R_{cm}.\ell/(100-\ell)\ R_{cm} = \ell/(100-\ell)$** **Or $R = S\ \ell/(100-\ell)$**	5

44	**a. How rms value of AC is related to its maximum value?** **b. With the help of a phasor diagram, explain how current leads emf in a capacitive circuit.** **Ans.a. $V_{rms} = V_m/\sqrt{2}$.** **b.Consider a circuit containing an AC source and a capacitor as shown in fig.** **The instantaneous voltage $v = v_m\sin\omega t$ … (i)** **Let C be the capacitance of the capacitor and q be the charge on the capacitor at that instant.**  **Then $q/C = v_m \sin\omega t$** **Or $q = C.v_m \sin\omega t$.** **The instantaneous current, $i = dq/dt = d/dt(C.v_m \sin\omega t)$** **$=C.v_m \cos\omega t.\omega=\omega C.v_m. \cos\omega t = \omega C.v_m. \sin(\omega t+\pi/2)$ [Since $\cos\theta = \sin(90+\theta)$]** **$= i_m \sin(\omega t+\pi/2)$. where $i_m = v_m/(1/\ \omega C)$.** **By comparing the instantaneous value of voltage and current, it is seen that current leads voltage by angle $\pi/2$.**	5

45	**Derive the equation for the refractive index of a material of a prism in terms of angle of prism A and angle of minimum deviation D.** **Ans. Consider a prism ABC. Let i and r_1 be angle of incidence and angle of refraction at first face AB. And the angle of incidence at second face AC is r_2 and angle of refraction (emergence) is 'e'.**  **Consider the quadrilateral AQNR,** **$<A + <QNR + <AQN + <ARN = 360$** **But $<AQN = <ARN = 90$.** **So $<A + <QNR = 180$ …(1)** **From triangle QNR,** **$r_1 + r_2 + <QNR = 180$ ………(2)** **From (1) & (2), we get $r_1 + r_2 = A$ ……….(3)** **From triangle MQR, exterior angle** **$d = <MQR + <MRQ$** **$= (i - r_1) + (e - r_2)$. $=(i + e) - (r_1 + r_2) = i+e - A$** **That is, deviation $d = i+e - A$. …. (4)** **The angle of deviation depends on angle of incidence. The variation of angle of deviation(d) and angle of incidence (i) is given in the figure below.** ***The deviation at which i&e are equal is called angle of minimum deviation D.***  **At minimum deviation position, i = e and hence $r_1 = r_2$** **Now the refracted ray (ray QR) inside the prism passes parallel to the base of the prism.** **Then $A = r_1 + r_2 = r + r = 2r$ Or $r = A/2$ …. (5)** **From eqn.(4),** **the minimum deviation $D = i+e - A$** **$= i+i - A = 2i - A$ (since $i = e$)** **Or $i = (A+D)/2$** **The refractive index of prism, $n_{21} = \sin i / \sin r = \sin(A+D)/2 \div \sin A/2$**	**5**