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| **Qn** | **Answer** | **Marks** |
| 1. (a) | (i) …an arrowed line showing the direction of travel of light. | 1 |
| (ii) …the angle between the incident ray and the reflecting surface | 1 |
| (iii)…the appearance of an image such that the left hand side of object has been interchanged with its right hand side but top and bottom remain | 1 |
| (b) | (i)   1. The reflected ray, the incident ray, and the normal to the mirror at the point of incidence all lie in the same plane. 2. The angle of incidence is equal to the angle of reflection | 1  1 |
| (ii) Verifying that the angle of incidence is equal to the angle of reflection.  I  O  P1  P2  P3  P4  *r i*  *i r*  M  M′  A1 A2  E1 N1 N2 E2   * A straight line is drawn on a white sheet of paper to divide the paper into about two equal parts. * Using four drawing pins, the paper is fixed onto a soft board on a horizontal bench. * A strip of plane mirror is placed vertically so that its silvered surface lies on the straight line. * An object pin O is stuck about 5 cm from the straight line. * While observing from position E1, sighting pins P1 and P2 are stuck so that they appear to be in a straight line with the image I of the object O as seen through the mirror. * The sighting pins are removed and their positions marked with small crosses. * The mirror and the pins are removed and the points P1, P2 are joined to intersect the mirror line MM′ at A1. * The same procedure is repeated while observing from position E2 and using sighting pins P3 and P4. * Normals A1N1 and A2N2 are drawn and the angles *i* and *r* are measured * The above steps are repeated for different positions of the eye, at least two on each side of the object.   It is observed that in each case ∠*i* = ∠*r* | 1  ½  ½  ½  ½  ½  ½  ½  ½ |
| P  O  M  N  I  O′  N′  I′  M′  (iii)  Suppose OO′ is an object in front of a plane mirror MM′. A ray ON, from O normal to MM′, is reflected back along the same path.  Another ray, OM, is reflected along MP and the two reflected rays appear to come from I, which is therefore the image of O.  Similarly, the ray O′N′ and O′M′ from O′, when they are reflected, appear to come from I′, which therefore is the image of O′.  Because of the laws of reflection, ∠MON = ∠MIN  and ∠M′O′N′ = ∠M′I′N′ it follows that the trapezia OO′M′M and II′M′M are congruent, with a common side MM′.  So ′ = ′ ⇒ same size | 1  ½  ½  ½  ½  ½  ½ |
| (c) | (i) …a situation in which a regular beam of light gets scattered on reflection by an uneven reflecting surface. | 1 |
| (ii) In diffuse reflection the rays in, say a parallel incident beam of light strike the surface at various angles of incidence.  Thus they are accordingly reflected in various directions. | 1  1 |
| (d) | M1  M2  O  P  Fig. 1  120o  20o  θ  60o  20o  α  α  According to the geometry of the figure, α = 180o – 120o – 20o = 40o  Now, θ = α + 60o  = 40o + 60o = **100o** | 1  1  1 |
|  | ***Total = 20*** |  |
| 2. (a) | ½(148 + 12) cm  148cm  12cm  ½ x 148 cm    (i) For Med to see the whole of himself, rays from the top of the head and those from the bottom of the feet must be reflected into his eyes.  So, as illustrated on the diagram the lowest edge of the mirror is ½ x 148 =  **74 cm** above the floor. | 1  1  1 |
| (ii) the minimum vertical dimensions, the height = ½(148 + 12)  = 80 cm | 1  1 |
| (b) | (i) With the incident ray fixed, if the mirror is rotated through an angle, the reflected ray rotates twice the angle | 1 |
| (ii) Here light is used as a weightless pointer.  In such instruments a small mirror M1 is rigidly attached to a system which rotates when a current flows in it.  M2 M1  A  2θ  X  O  L  Lamp  Y  θ              A beam of light from a fixed lamp L is directed on to the mirror.  When no current is flowing through the system, the beam is normal to M1, and it is reflected directly back to give a spot of light at O on scale Y (just above L).  If a current passes through the system so that the system rotates by θ, the reflected beam rotates through 2θ, thus making the system sensitive. | ½  1  ½  1  1 |
| (c) | (i)  A  Caustic surface  F  Wide beam  When a wide beam of light, parallel to the principle axis, is incident on a concave mirror the reflected rays do not pass through a single point as a narrow beam does.  The subsequent reflected rays meet at other points before the principal axis.  The locus of such points forms a bright surface known as the ***caustic surface*.** | 1  1  1  1 |
| (ii) Parabolic reflector  Wide parallel reflected beam  F  A parabolic mirror is capable of producing a wide parallel beam of light when the source of light is placed at its principal focus.  If the source were to be placed at the principal focus of a spherical mirror, only those rays which strike near the pole are reflected as a parallel beam. The rest are reflected divergently.  O  C  I  X  α  β  γ  N  P  v  r  u  θ  θ | 1  1  1 |
| (d) | Consider a point object O on the principle axis of a convex mirror.  A ray OX from O is reflected along XI.  A normal at X must be passing through the centre of curvature of the mirror. So C is the centre of curvature.  A ray OP, incident at the pole P, is reflected back along PO and the point I where the reflected rays meet is the image of O.  From the geometry of the figure  α + θ = β……….……………..(1)  Also β + θ = γ……….………………(2)  Therefore from (1) and (2)  α + γ = 2β …………………………(3)  Now, γ = h/IN = h/(IP) as I is virtual.  α = h/ON = h/(OP) as O is real  β = h/NC = h/(PC) as C is real  Substituting for α, β and γ in (3)  h/(OP) + h/(IP) = 2h/(CP)  So 1/OP + 1/IP= 2/CP  1/u + 1/v = 2/r      ALTERNATIVE DERIVATION  u  Q  R  O  P  S  v  f  I  h1  h2  F  Imagine an object OQ of height h1 at O.  A ray QR parallel to the principal axis is reflected through F, the principal focus.  A ray QP, incident at the pole, is reflected through S such that ∠QPO = ∠SPI and the point, S, where the two reflected rays meet is the image of Q.  Also I is the image of O since O is on the principal axis, and IS is the image of OQ.  Now ΔQPO is similar to ΔSPI    And ΔSIF is similar to ΔRPF  ***(Convex mirror approach is also acceptable)*** | ½  ½  ½  ½  ½  ½  ½  ½  ½  ½ |
| ***Total = 20*** | | |
| 3. (a) | (i) When materials are rubbed together, the heat generated due to friction raises the kinetic energy of the electrons on the periphery of the atoms.  The material with the lower work function loses some of its electrons to the other.  The material that loses electrons becomes positively charged while the one gaining them becomes negatively charged. | 1  1  1 |
| (ii) Charging by rubbing is possible in insulators because any charge acquired by any part of such a material does not flow away to other parts – it stays. | 1 |
| (b) | A  The conductor, A, is supported on an insulator and given a charge.  Proof planes of the same area, but shaped to fit the various respective parts of the conductor, are prepared.  A proof plane (on an insulating handle) at a time is placed on the part it fits and charged by induction  Then the charged proof plane is transferred to the inside of a hollow can connected to the cap of a neutral electroscope (without making contact with the can), each time noting the divergence of the leaf.  It is observed that proof planes from sharper parts cause greater divergence.  This implies that ***surface density*** (charge per unit area) increases with curvature. | ½  ½  1  1  1  1 |
| (c) | (i) … the piling of electrons on one side of a conductor, leaving a positive charge on the opposite side it, due to presence of a charge nearby. | 1 |
| (ii)  *Pattern @1*  *Direction @1* | 2 |
| \_ \_ \_ \_ \_  + + + + +  \_ \_ \_ \_ \_ \_ \_  Neutral conductor  Negatively charged body  (iii)  When the two bodies are close together, electrostatic induction occurs in the conductor as shown. i.e. a charge opposite to that on the body comes near the body.  Since unlike charges are near each other, attraction between the two bodies occurs. | 1  1  1 |
| (d) | Hollow can  Insulator   * A hollow metallic can is placed on an insulator and connected to a neutral electroscope. * A metal ball, is suspended from a silk thread, given a positive charge and lowered into the can, without touching its walls.   The leaf is observed to diverge, and as long as the ball is inside the can no change of deflection occurs even when it is moved about within the can.  This shows that the outside acquires a charge   * The ball is allowed to touch the inside   Still the deflection is unchanged. This shows that the outside did not lose or gain any charge.   * Finally, the ball is removed.   The deflection still remains unchanged, and when tested with another electroscope, the ball is found to have lost all the charge; also, the inside of the can has no charge. | ½  1  ½  ½  ½  ½  ½  1 |
| ***Total = 20*** | | |
| 4. (a) | (i) … the region in which an electric force is detected | 1 |
| (ii) The electric potential at a point in a field is the work done in moving a positive charge of one coulomb from infinity to the point. | 1 |
| (b) | Imagine a small point charge +q placed at point P.  +Q ­+q  d  P  E    By Coulomb’s law, the force on +q is  F =  But E is the force per unit charge.  i.e. E = | ½  ½  1  1 |
| (c) | 10cm  6cm  8cm  Q1  Q2  P  (i)  Let V1 = potential at P due to Q1  and V2= potential at P due to Q2  Then V1 =  = 9.0 x 109 x  = -6.0 x 105 V  V2 =  = 9.0 x 109 x  = 11.25 x 105 V  Vp = V1 + V2 = (-6.0 + 11.25) x 105  = **5.25 x 105 V** | 1  1  1  1 |
| (ii) Let E1 = electric intensity at P due to Q1  and E2= electric intensity at P due to Q2  Then E1 =  = 9.0 x 109 x  = -1.0 x 107 NC-1  E2 =  = 9.0 x 109 x  = 1.4 x 107 NC-1  Ep  E1  E2    = (12 + 1.42) x 1014  = 2.96 x 1014  ∴ Ep = **1.72 x 107 NC-1** | 1  1  1  1 |
| (ii) Let y = distance of Y from Q1  Then  +  ∴  ∴ 20 – 2y = 5y  ∴ y =  = **2.86 cm from Q1** | 1  1  1 |
| (iii) Force on a charge at Y = charge x intensity at Y  Intensity at Y = vectorial sum of the intensities there  Now, E1 =  = 9.0 x 109 x  = -4.40 x 107 NC-1  and E2 =  = 9.0 x 109 x  = 1.76 x 107 NC-1    E1  E2  So intensity at Y =  = (4.40 + 1.76) x 107  = 6.16 x 107 NC-1  ∴ Force on 3μC = 3 x 10-6 x 6.16 x 107  = **184.8 N towards Q1** | 1  1  1  1 |
| ***Total = 20*** | | |