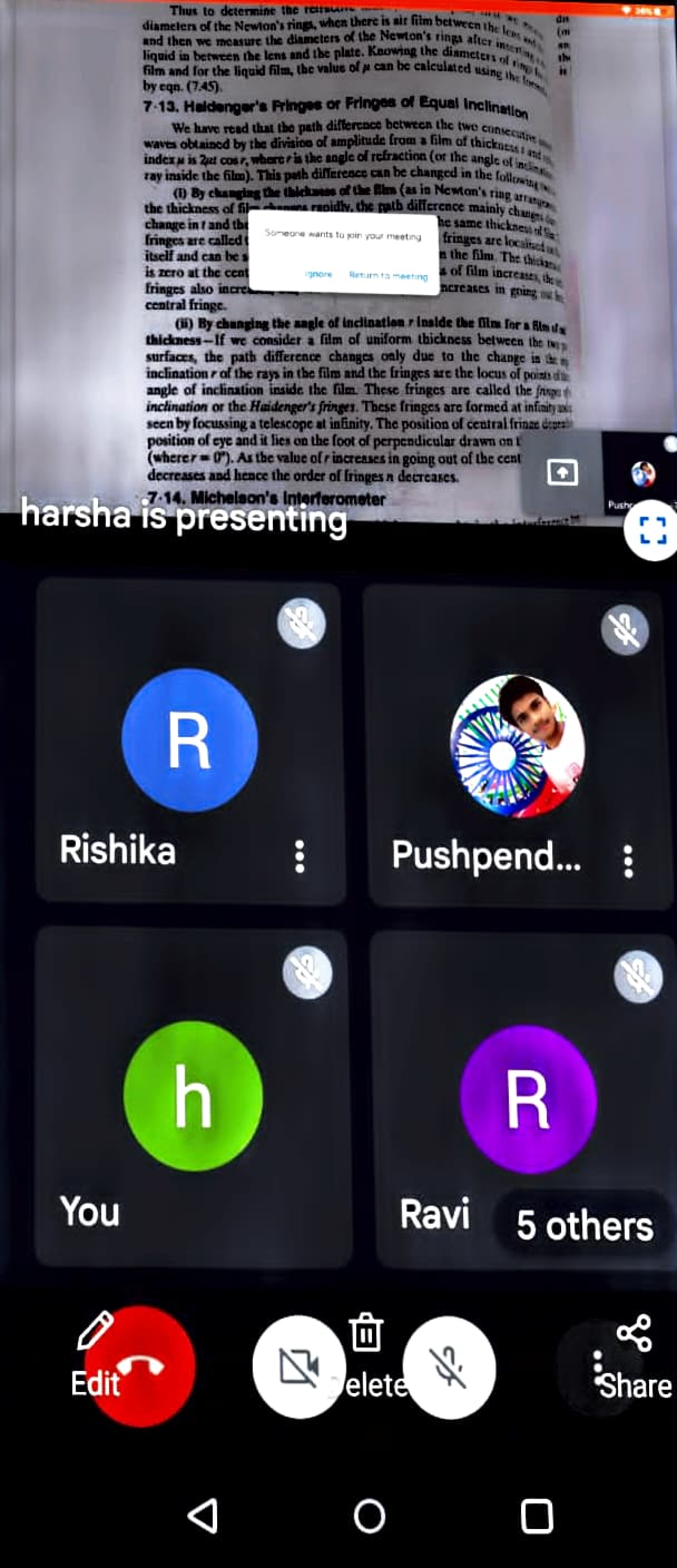

Thus to determine the refractive ... diameters of the Newton's rings, when there is air film between the lens and ... and then we measure the diameters of the Newton's rings after inserting ... liquid in between the lens and the plate. Knowing the diameters of rings ... film and for the liquid film, the value of μ can be calculated using the form... by eqn. (7.45).

7·13. Haidenger's Fringes or Fringes of Equal Inclination

We have read that the path difference between the two consecutive ... waves obtained by the division of amplitude from a film of thickness t and ... index μ is $2\mu t \cos r$, where r is the angle of refraction (or the angle of inclin... ray inside the film). This path difference can be changed in the following ...

(i) By changing the thickness of the film (as in Newton's ring arrange... the thickness of fil[illegible] rapidly, the path difference mainly changes ... change in t and the ... the same thickness of ... fringes are called t... fringes are localised ... itself and can be s... the film. The thickness ... is zero at the cent... of film increases, the ... fringes also increa... increases in going out ... central fringe.

(ii) By changing the angle of inclination r inside the film for a film of ... thickness—If we consider a film of uniform thickness between the two ... surfaces, the path difference changes only due to the change in the ... inclination r of the rays in the film and the fringes are the locus of points of ... angle of inclination inside the film. These fringes are called the *fringes of ... inclination* or the *Haidenger's fringes*. These fringes are formed at infinity and ... seen by focussing a telescope at infinity. The position of central fringe depends ... position of eye and it lies on the foot of perpendicular drawn on t... (where $r = 0°$). As the value of r increases in going out of the cent... decreases and hence the order of fringes n decreases.

7·14. Michelson's Interferometer

Let $\frac{E - E_C}{kT} = x$, then $dE = kT\,dx$

Then
$$n_e = \frac{4\pi(2m)^{3/2}}{h^3} e^{(E_F - E_C)/kT} \int_0^\infty (kTx)^{1/2} e^{-x} (kT\,dx)$$
$$= \frac{4\pi(2mkT)^{3/2}}{h^3} e^{(E_F - E_C)/kT} \int_0^\infty x^{1/2} e^{-x} dx$$

But from standard integral, $\int_0^\infty x^{1/2} e^{-x} dx = \left(\frac{\pi}{4}\right)^{1/2}$

$\therefore$
$$n_e = \frac{4\pi(2mkT)^{3/2}}{h^3} e^{(E_F - E_C)/kT} \left(\frac{\pi}{4}\right)^{1/2}$$

or
$$n_e = e^{-\Delta E/2kT} \times \frac{4\pi}{h^3} (2mkT)^{3/2} \left(\frac{\pi}{4}\right)^{1/2}$$

since $E_C - E_F = \frac{1}{2}\Delta E$, where ΔE is the forbidden energy gap.

or
$$n_e = AT^{3/2} e^{-\Delta E/2kT}$$

where $A = \frac{4\pi}{h^3}(2mk)^{2/3}\left(\frac{\pi}{4}\right)^{1/2}$ is a constant. The value of this [illegible] is $4{\cdot}28 \times 10^{21}$ per $m^3\,K^{3/2}$.

Similarly, hole density in the valence band

$$n_h = \int_0^{E_V} \frac{4\pi(2m)^{3/2}}{h^3} (E_V - E) \ldots$$

or
$$n_h = e^{-\Delta E/2kT} \times \frac{4\pi}{h^3} (2mkT)^{3/2} \ldots$$

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produced in a body is directly proportional to the stress applied on it. Hence within the limit of elasticity, more the deforming force applied on the body, more is the change produced in the size or shape of that object. Remember that Hooke's law is applicable only when the deforming force applied on the object is small (*i.e.*, the deforming force is within the limit of elasticity).

Hence according to Hooke's law, *within the elastic limit, more the stress applied on a body, more is the strain produced in that body i.e., stress is always directly proportional to the strain* or in other words, the ratio of stress to strain is a constant. *i.e.*,

$$\text{stress} \propto \text{strain}$$

or

$$\frac{\text{stress}}{\text{strain}} = \text{constant} = E \text{ (modulus of elasticity)} \quad ...(3.5)$$

The constant E is called the *modulus of elasticity* of material of the body. Its value depends on the material of the body and is different for different materials. Its S.I. unit is newton/metre^2.

3.4. Elastic Constants for an Isotropic Soild

Here we shall consider the homogeneous and isotropic substances or bodies in which the elastic properties are the same at all points and in all directions. All the solids are generally not homogeneous and isotropic. For example, wood, crystal and metals of crystal structure are heterogeneous and anisotropic (*i.e.*, their elastic properties are different at different points and in different directions). The metals which can be obtained in the form of rod or wire, can be assumed to be homogeneous and isotropic. On the other hand all liquids and gases (*i.e.*, fluids) are generally homogeneous and isotropic.

There are the following three modulii of elasticity of a homoge
material : (i) Young's modulus, (ii) Bulk modulus, and (iii) Modulus

If on applying the force, the change is produced in the lengt
the ratio of longitudinal stress to longitudinal strain is known as
elasticity.

If on applying the force, the change is produced in the volume of the body the
the ratio of normal stress to volume strain

The quantity YI is called the *flexural rigidity*.

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Geometrical moment for a beam of (i) rectangular cross-section and (ii) circular cross-section

(i) For rectangular cross-section : Consider a beam of rectangular cross-section of breadth b and width d. We are to find its geometrical moment about the axis MN (Fig. 3.13).

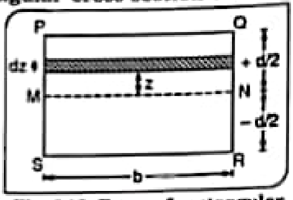

Fig. 3.13. Beam of rectangular cross-section

Let there be a layer of width dz at a distance z above the axis MN. The area of cross-section of this layer $= b\ dz$.

$\therefore$ Geometrical moment of this layer about the axis MN $= (b\ dz)z^2$

The geometrical moment of total section of the beam about the axis MN can be obtained by integrating the above expression for $z = -d/2$ to $z = +d/2$. *i.e.*,

$$I = \int_{-d/2}^{+d/2} (b\ dz)z^2 = b\left(\frac{z^3}{3}\right)_{-d/2}^{+d/2} = \frac{2b}{3}\left(\frac{d}{2}\right)^3 = \frac{bd^3}{12} \qquad ...(3.39)$$

(ii) For circular cross-section : For a beam of circular cross-section of radius r, geometrical moment of an element will be $(\pi z\ dz) \times z^2$ and the integrating limits will be from $z = 0$ to $z = r$, *i.e.*,

$$I = \int_0^r (\pi z\ dz) \times z^2 = \pi\left(\frac{z^4}{4}\right)_0^r = \frac{\pi r^4}{4}$$

If the beam is hollow and the internal radius is r_1 and external radius is r_2

$$I = \int_{r_1}^{r_2} (\pi z\ dz) \times z^2 = \pi\left(\frac{z^4}{4}\right)_{r_1}^{r_2} = \frac{\pi(r_2^4 - r_1^4)}{4} \qquad ...(3.41)$$

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The potential energy stored per unit area of the surface is called the ... *energy.*

In Fig. 3.24, ABCD is a rectangular frame of wire, on which another wire GH can slide without friction. A film is formed within the frame by immersing it in the soap solution. The film has the two rectangular surfaces : the upper surface and the lower surface.

The force on the wire GH due to surface tension is $F = T \times 2l$, which acts inwards and tends to contract the film. Here T is the surface tension of the liquid (*i.e.*, the force acting on unit length) and l is the length of the wire GH. Here the length has been taken as $2l$ because of the two free surfaces of the film. To keep the wire GH at its position, a force equal to F acting outwards, is required on it. If the wire GH is displaced through a distance x by the force F, the ... done on the wire (*i.e.*, the increase in potential energy) is

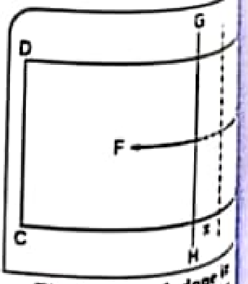

Fig. 3.24. Work done in sliding a wire on a film

$$W = F \times x$$

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But $F = T \times 2l$ ∴ $W = (T \times 2l)x = T \times \Delta A$ ...(3.72)

where ΔA = increase in the area of film $= l \times x + l \times x = 2lx$ (because of the two surfaces of the film)

If in eqn. (3.72), $\Delta A = 1\ m^2$, then T = W joule

Hence *the surface tension of a liquid is equal to the work required ... the surface area of the liquid film by unity at a constant temperature.* Thus ... of surface tension can also be expressed as J/m^2.

Work done in formation of a bubble—A bubble has the two free surfac... the bubble is hollow from inside. Therefore the work needed to form a soap bubble of ...

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