Thin Film Interference

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- **Exercise :**
  Explain - why we have to consider thin film to obtain stationary interference pattern? Estimate the order of thickness of the film from this idea.

- **Film :**

  a) Uniformly thick film (parallel interfaces)
  b) Non-uniform thickness (wedge shaped with very small wedge angle)

- **Source :**

  a) Point source
  b) Extended source (collection of large nos. of point sources.)

Point source and uniformly thick film

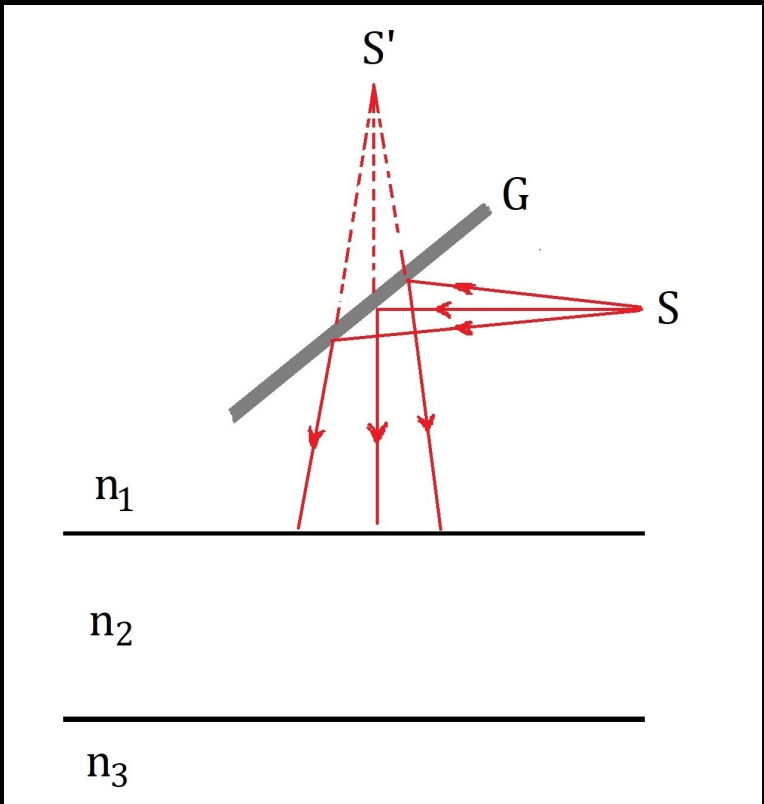
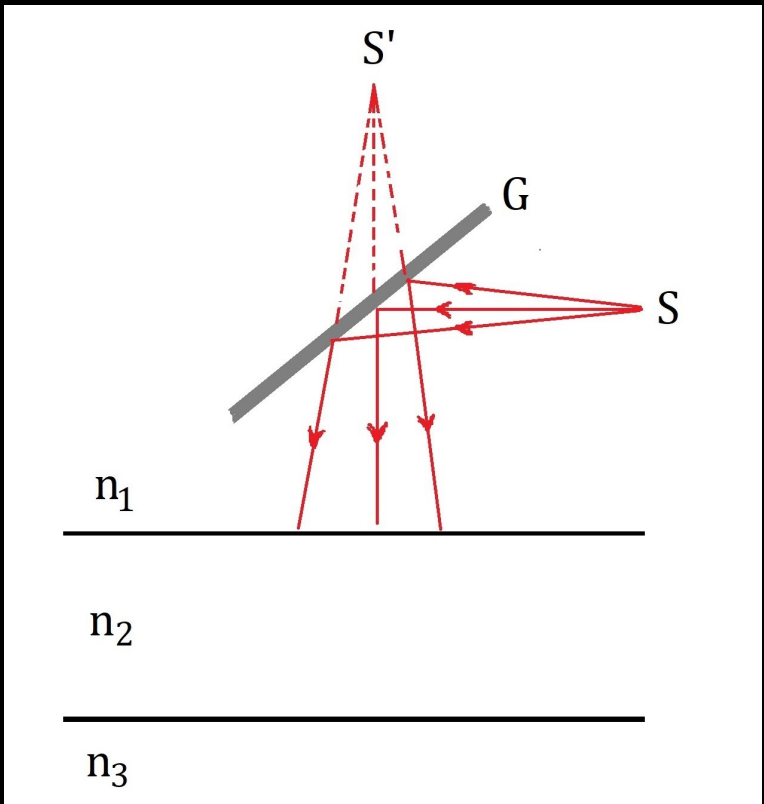


Figure: Experimental set-up

- Two parallel interfaces of the thin film is separating three media of refractive indices n_1, n_2 and n_3.
- S is the point source. The film is illuminated by the reflected light from partially reflecting plate G. This is used to avoid interfering of light coming directly from source.
- Apparently light rays are falling on the film from virtual source S'.
- After getting reflected from upper and lower surfaces, the light rays gives rise to interference patterns.



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- Apparently light rays are falling on the film from virtual source S'.
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- In the subsequent discussions we will not draw explicit diagram of experimental set-ups. The point sources will be considered to be the virtual images of the original sources produced by **partially reflecting** plate.

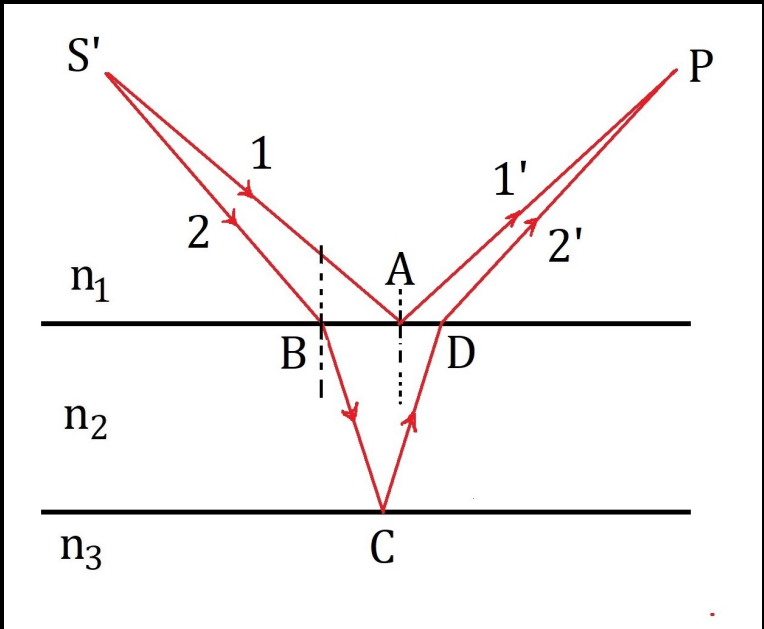
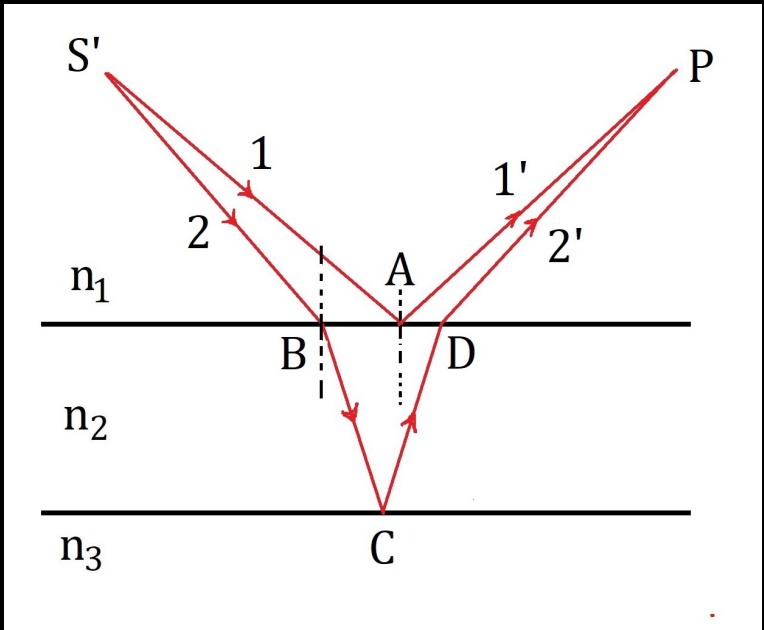


Figure: **Situation-I**

- S' is the image of original point source.
- The ray $1-1^{'}$ is reflected from upper surface and ray $2-2^{'}$ is reflected from lower surface. Finally they meet at P.
- **Path difference:**

$$\Delta = [n_1 S'B + n_2(BC + CD) + n_1 DP] - n_1(S'A + AP)$$

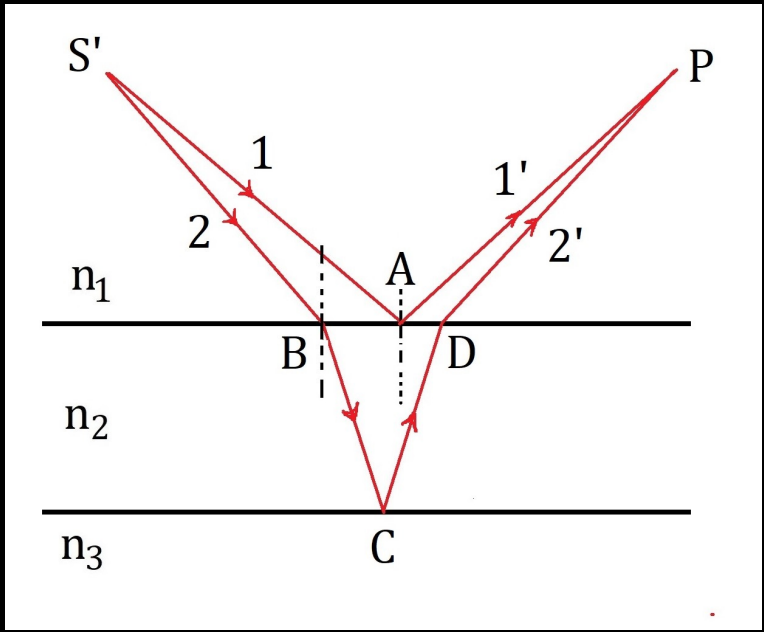
- Depending on the value of this optical path difference and considering the phase reversal due to reflection (if occurs) we will observe bright or dark patch at P.

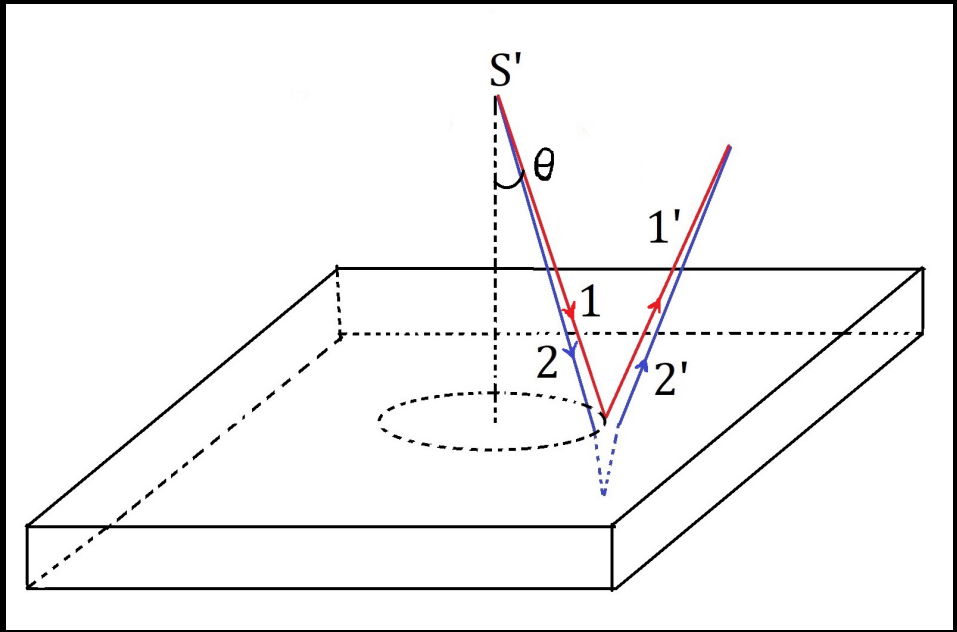


- **Exercise :**

  Obtain the allowed values of Δ as multiple of $\lambda/2$ to have constructive or destructive interference at P for the following cases.

  a) $n_1 > n_2 > n_3$
  b) $n_1 = n_3 < n_2$
  c) $n_1 < n_2 < n_3$
  d) $n_1 > n_2 = n_3$





- Formation of interference effect at some point is circularly symmetric. Same angle of ray emission about the vertical can be realized by a cone with vertex at S'.
- If one places a screen parallel to the surface e of thin film, a concentric circular fringe pattern will be observed.
  Each of the circular fringe is of same depression angle θ.

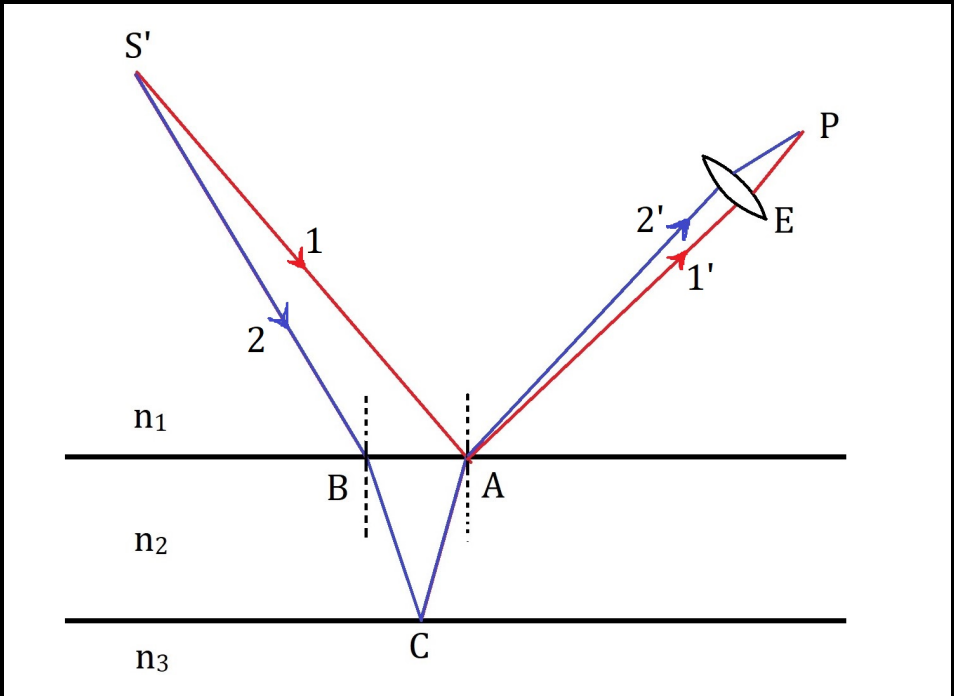
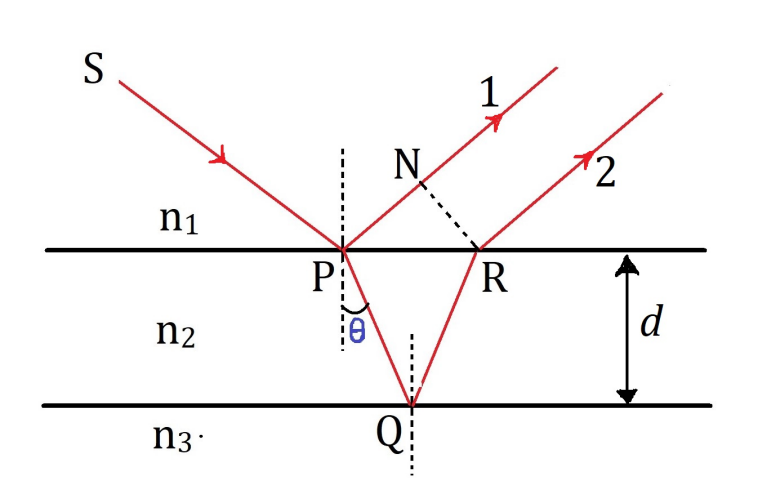
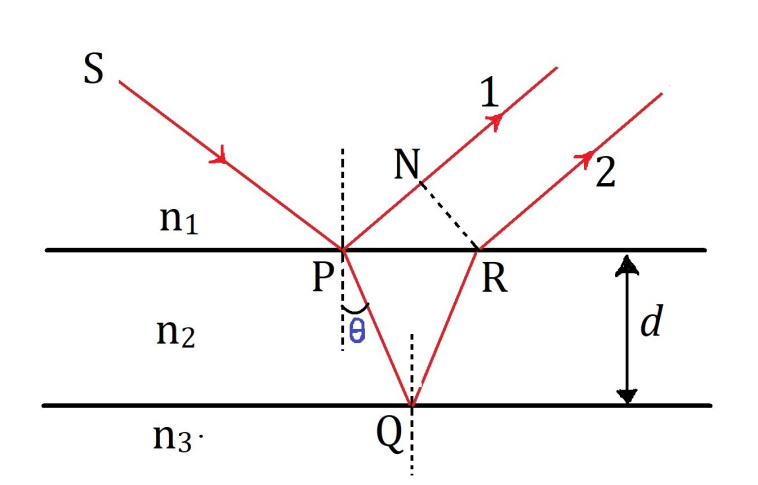


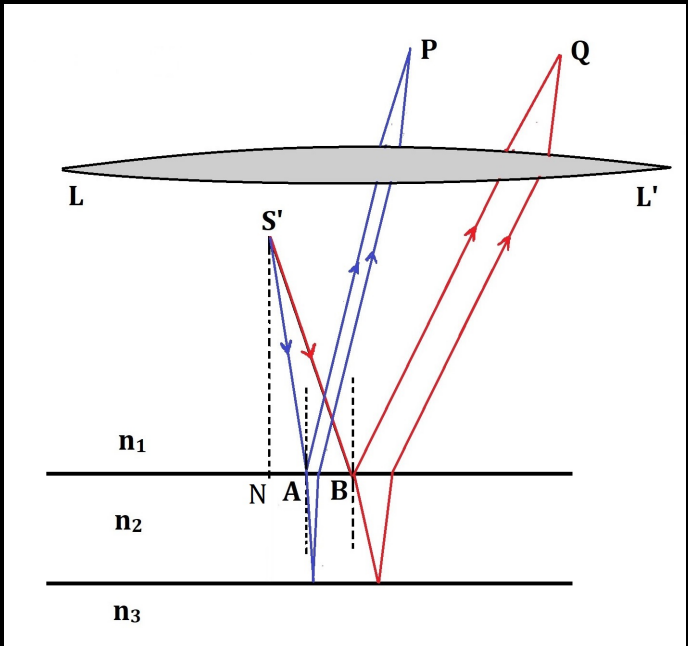
Figure: **Situation - II**

- If we look at the film, rays from a small portion will enter our eye to produce interference effect on our retina.
- Optical path difference will decide whether we observe bright or dark patch at point A.

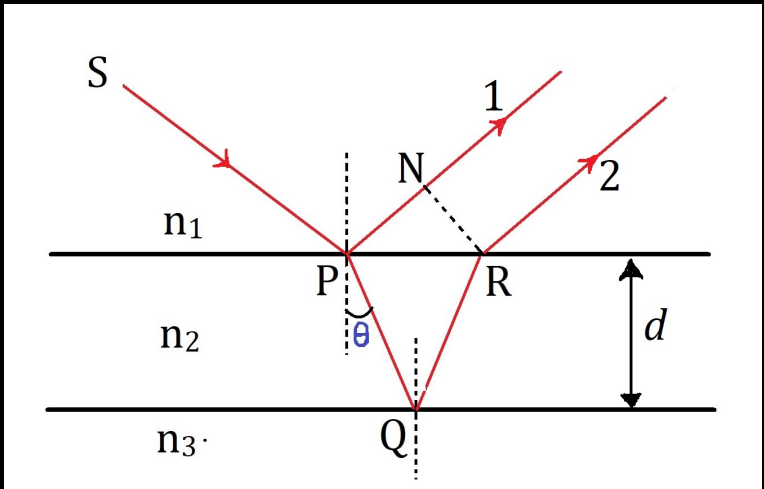


- Ray-1 (reflected from upper surface) and ray-2 (reflected from lower surface) are parallel because the reflecting surfaces are parallel.
- If we focus our eye for infinity, parallel rays will be focused on retina & will produce interference effect on the retina.





- Ray-1 (reflected from upper surface) and ray-2 (reflected from lower surface) are parallel because the reflecting surfaces are parallel.
- If we focus our eye for infinity, parallel rays will be focused on retina & will produce interference effect on the retina.
- Light rays emanating with two different angles produces interference fringe at two different points on the focal plane of lens. It is general for all light rays emanating from S.
- The system has cylindrical symmetry about vertical. So, we will have concentric dark bright rings as interference fringes.



- **Exercise :**

  Show that the optical path difference,

  $$\Delta = n_2(PQ + QR) - n_1 PN = 2n_2 d\cos\theta$$

  This is known as *cosine law*

Extended source and uniformly thick film