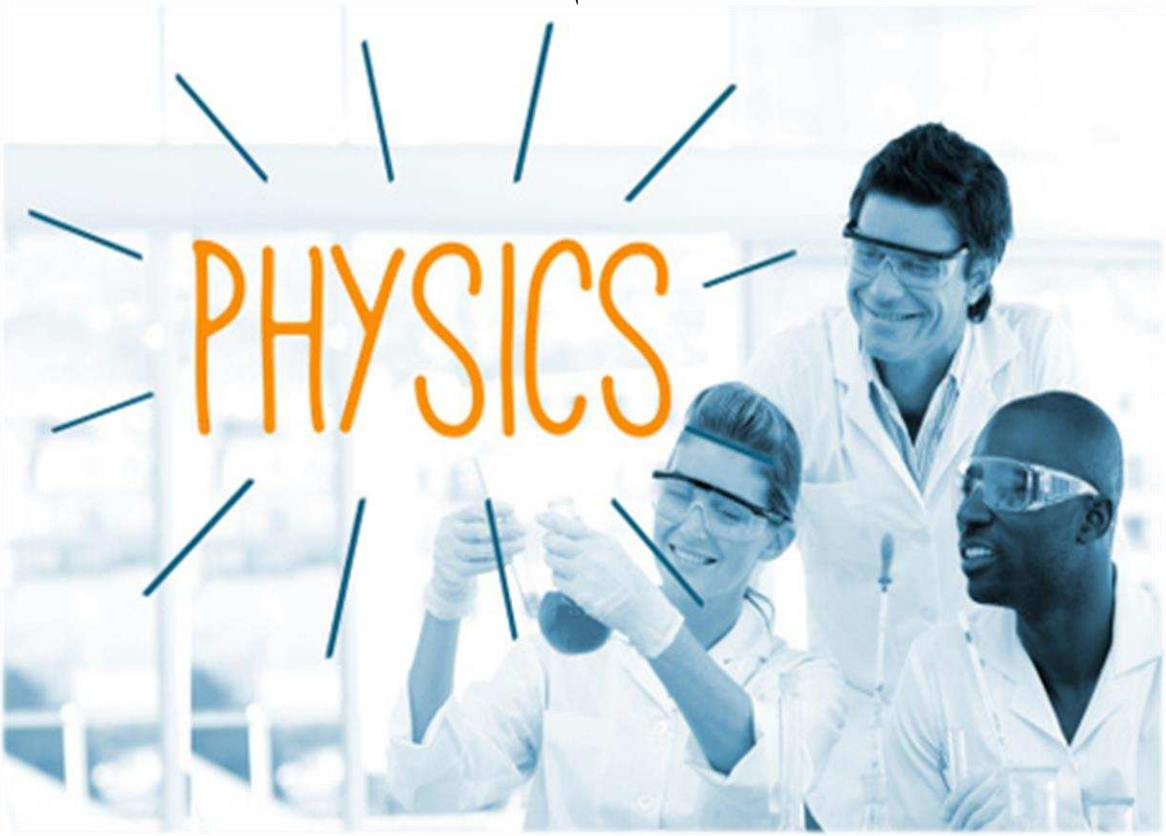
مركز أم الامارات



Grade 12 General / physics
Trimester 3 / Academic Year 2019-2020

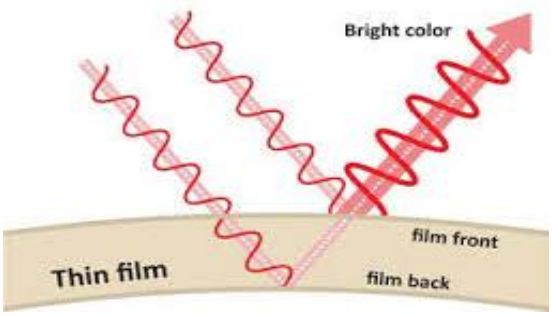
I Physics

Interference part 2

Thin-Film Interference

1- **What is the reason for the emergence of a spectrum of colors on a soap bubble or on the oily film on a water puddle in a parking lot?**
This happen as a result of the constructive and destructive interference when light waves reflect from separate surfaces of a thin film this phenomenon called ***thin-film interference.***

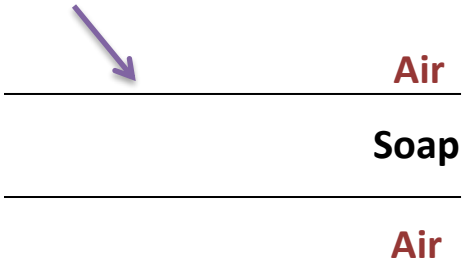
- **Note:** The interference occurs between two reflected waves, one reflects from the outer surface of the thin film and the other from the inner surface of the thin film, and we can get two types of interference (constructive or destructive)



2- **There are two possibilities for the phase difference between the incident and the reflected rays.**

	Possibility	The phase difference
1	The light falls from a medium with a large refractive index to a medium with a small refractive index ($n_1 > n_2$). Slow to fast	The incident and the reflected rays are in phase The wave does not invert
2	The light falls from a medium with a small refractive index to a medium with a large refractive index ($n_1 < n_2$). Fast to slow	The incident and the reflected rays are out of phase by (π) The wave inverts

➢ **Note**: In the soap film, the arrangement of the media is as follows:



3- Rely on the following figures to fill in the tables.

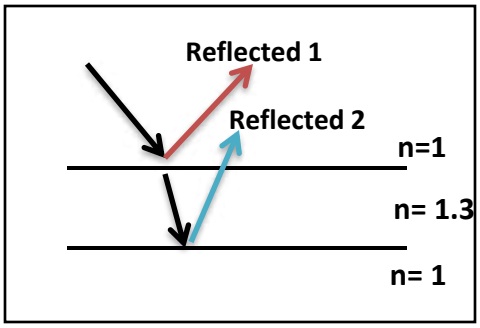


Figure A

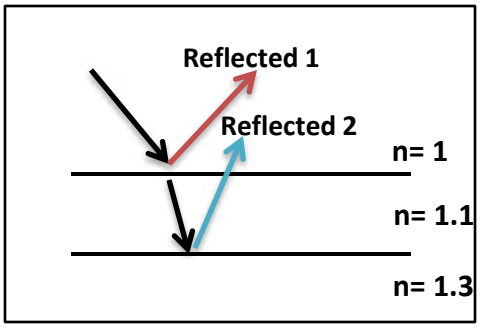


Figure B

Figure A	
The Reflected ray	Does the reflected ray invert?
Reflected ray 1	
Reflected ray 2	

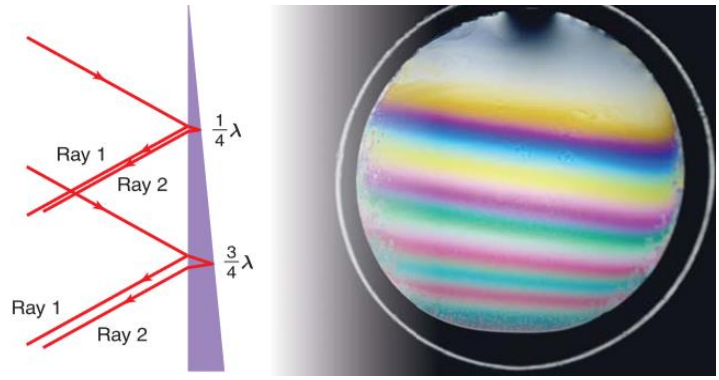
Figure B	
The Reflected ray	Does the reflected ray invert?
Reflected ray 1	
Reflected ray 2	

Important note: The type of interference will depend on:

- ✓ The number of inversions
- ✓ The thickness of the thin film

4- In the soap bubble, what are the thicknesses of the film that cause a constructive interference? (one inversion)

The constructive interference occurs on the soap bubble when the thickness of the film is equal to *odd numbers* of a quarter of the wavelength. $1\lambda/4\,, 3\lambda/4\,, 5\lambda/4\ \ldots etc$



$$\boxed{d = m\,\lambda/4} \qquad m = 1,3,5,7,\ldots$$

5- In the thin films (if two inversions or no inversions occurs), what are the thicknesses of the film that cause a constructive interference?

The constructive interference occurs on the thin film when the thickness of the film is equal to *integer numbers* of a halfe of the wavelength. $1\lambda/2\,, 2\lambda/2\,, 3\lambda/2\,, \ldots etc$

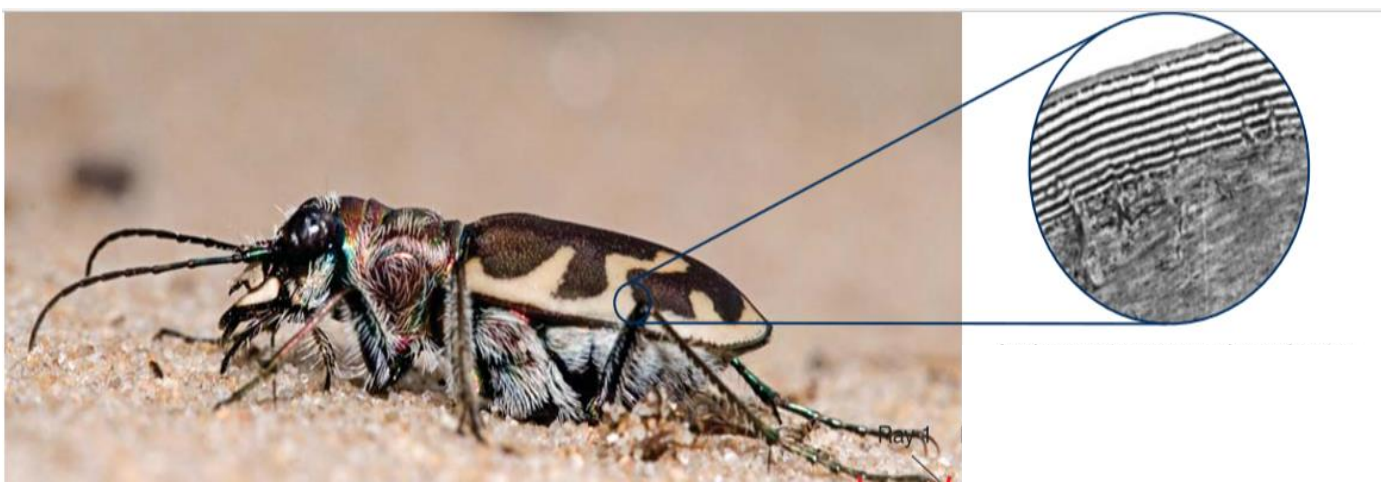
$$\boxed{d = m\,\lambda/2} \qquad m = 1,2,3,4,\ldots$$

Important rules to calculate the thickness of the thin film in case of (destructive or constructive) interference.

In case of constructive interference	
One of the reflected waves inverted.	$2d = \left(m + \frac{1}{2}\right)\frac{\lambda}{n_{film}}$ $m = 0,1,2,3,4,\ldots.$
Both reflected waves inverted or not	$2d = m\,\frac{\lambda}{n_{film}}$ $m = 1,2,3,4,\ldots.$

In case of Destructive interference	
One of the reflected waves inverted.	$2d = m\,\dfrac{\lambda}{n_{film}}$ $m = 1,2,3,4, \ldots.$
Both reflected waves inverted or not	$2d = \left(m + \dfrac{1}{2}\right)\dfrac{\lambda}{n_{film}}$ $m = 0,1,2,3,4, \ldots.$

6- Light interference also occurs naturally in the outer layer of the shells of many beetles, as shown in the figure. The shimmering green of the tiger beetle is the result of reflection from thin, parallel layers of chitin and sometimes other materials that differ in refractive index.

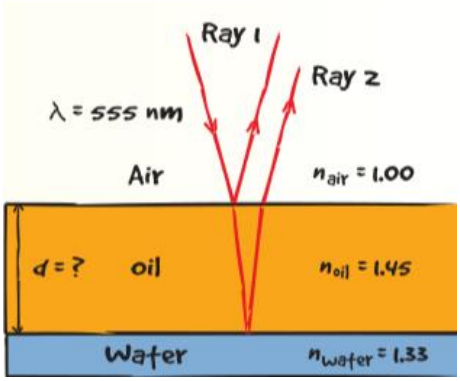


7- To solve the thin film problems, follow these steps:

A. Determine the type of the interference.
B. Determine the number of the inversions.
C. Chose the correct rule from the table.

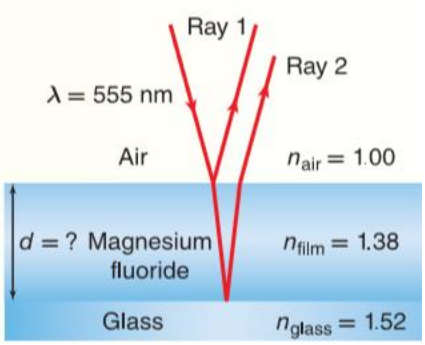
Applications

1- **You observe colored rings on a puddle and conclude that there must be an oil slick on the water. You look directly down at the puddle and see a yellow green (λ = 555 nm) region. If the refractive index of oil is 1.45 and that of water is 1.33, what is the minimum thickness of oil that could cause this color?**



2- **In the previous problem, what would be the thinnest film that would create a reflected red (λ = 635 nm) band**

3- **A glass lens has a nonreflective coating of magnesium fluoride placed on it. How thick should the nonreflective layer be to keep yellow-green light with a wavelength of 555 nm from being reflected? See the sketch in the figure.**



4- You can observe thin-film interference by dipping a bubble wand into some bubble solution and holding the wand in the air. What is the thickness of the thinnest soap film at which you would see a black stripe if the light illuminating the film has a wavelength of 521 nm? Use n = 1.33 for the bubble solution

5- What is the thinnest soap film (n = 1.33) for which light of wavelength 521 nm will constructively interfere with itself?

6- A silicon solar cell has a nonreflective coating placed on it. If a film of silicon monoxide, n = 1.45, is placed on the silicon, n = 3.5, how thick should the layer be to keep yellow-green light (λ = 555 nm) from being reflected?

The end