Unit 11 - Week 10

Week 10 Assignment 10

The due date for submitting this assignment has passed. As per our records you have not submitted this assignment. Due on 2018-10-10, 23:59 IST.

1) ALL questions in this assignment are of MULTIPLE correct option type.

Consider the propagation of a shear acoustic wave along z direction in an anisotropic medium. $K_T$ is the propagation constant and $\Omega$ is the frequency of acoustic wave. There are two degenerate orthogonal modes possible in this situation.

(A) one such mode can be represented by $u(x,t) = x \cos(K_T x - \Omega t)$

(B) one such mode can be represented by $u(x,t) = x \cos(K_T x + \Omega t)$

(C) in anisotropic medium the velocity of propagation of both these orthogonal modes are different

(D) in case of isotropic medium the velocity of propagation of both these orthogonal modes are same

No, the answer is incorrect.

Score: 0

Accepted Answers:

(A)
(D)

2) For a $y$-polarised shear acoustic wave along $z$ direction in an anisotropic medium having $K_T$ as the propagation constant and $\Omega$ the frequency of acoustic wave,

(A) all normal strain components are zero

(B) only non-vanishing shear strain component is $S_{xy} = S_{yx}$

(C) the velocity of propagation of the wave is given by $v_T = \frac{n}{K_T}$

(D) the equation to this acoustic wave mode can be represented by $u(x,t) = y \cos(\Omega t - K_T x)$

(A)
Q.3- Q.7 are based on the following paragraph
Consider the propagation of a y-polarized transverse acoustic wave along z direction in LiNbO$_3$ crystal. The strain-optic tensor for this crystal is given by $\mathbf{p}_{\text{eff}} =$

$$
\begin{pmatrix}
0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0
\end{pmatrix}
$$

and the index ellipsoid is given by the equation $\frac{x^2}{n_1^2} + \frac{y^2}{n_2^2} + \frac{z^2}{n_3^2} = 1$.

Which of the following relations yield(s) non-zero strain component(s) in this case?

(A) $\frac{1}{2} (\frac{\partial u_x}{\partial x} + \frac{\partial u_y}{\partial y})$

(B) $\frac{1}{2} (\frac{\partial u_y}{\partial x} + \frac{\partial u_x}{\partial y})$

(C) $\frac{1}{2} \frac{\partial u_y}{\partial x}$

(D) $\frac{1}{2} \frac{\partial u_x}{\partial y}$

No, the answer is incorrect.
Score: 0

Accepted Answers:
(C)

4)

Which of the following components of impermeability change ($\Delta \eta$) tensor is/are non-zero in this case?

(A) $\Delta \eta_1$

(B) $\Delta \eta_2$

(C) $\Delta \eta_3$

(D) $\Delta \eta_4$

No, the answer is incorrect.
Score: 0

Accepted Answers:
(A)

(D)
Which of the following is/are correct about the elements of permittivity change ($\Delta \varepsilon$) tensor in this case?

(A) $\Delta \varepsilon_1 = -\varepsilon_0 \mu_4 S_4 n_0^2$

(B) $\Delta \varepsilon_2 = -\varepsilon_0 \mu_4 S_4 n_0^2$

(C) $\Delta \varepsilon_3 = -\varepsilon_0 \mu_4 S_4 n_0^2$

(D) $\Delta \varepsilon_6 = \varepsilon_0 \mu_4 S_4 n_0^2$

No, the answer is incorrect.

Score: 0

Accepted Answers:

1 point

As regards the equation to the modified index ellipsoid in presence of the acoustic wave, which of the following is/are correct?

(A) The rotation angle of the ellipsoid w.r.t. old coordinate system is $\delta = \frac{1}{2} \tan^{-1} 2K / \left( \frac{1}{n_0^y} - \frac{1}{n_0^x} \right)$

(B) The modified ellipsoid has undergone a rotation about the $x$-axis

(C) All new RI's are modified by the presence of acoustic wave

(D) The new principal RI along the $x'$ direction is $n_{x'} \approx n_x - \frac{1}{2} \mu_4 S_4 n_0^2$

No, the answer is incorrect.

Score: 0

Accepted Answers:

1 point

$\text{LiNbO}_3$ is a naturally uniaxial crystal. In presence of the travelling shear acoustic wave in the configuration as above, the crystal medium carries a travelling 3d volume-index grating (phase grating)

(A) In this case, the phase grating travels along the direction of polarisation, i.e., along $y$

(B) The grating constant can be expressed as $K_T = 2\pi / \lambda$

(C) The speed with which the grating travels with in the medium is given by $v_T = \Omega / K_T$

(D) The grating is formed by a time-independent constant strain imparted by the acoustic wave

No, the answer is incorrect.

Score: 0

Accepted Answers:

(B)
8) **Q.8 - Q.12 are based on the following paragraph**
Let us consider an acoustic wave propagation along z-axis in a medium resulting moving periodic RI grating given by \( n(x, t) = n_0 + \Delta n \sin(\Omega t - K z) \). Here \( \Omega \) is the angular frequency and \( K \), the propagation constant of acoustic wave such that the wavelength of the wave is \( \lambda \). Also, \( n_0 \) represents the RI in absence of acoustic wave and \( \Delta n \), the peak RI change due to acoustic wave. A light wave of wavelength \( \lambda_0 \) passing through this medium undergoes diffraction.

There are two possible types of diffraction of a light beam that may occur under this situation.

(A) If the length of acoustic wave over which the optical beam interacts is short, \( L \ll \frac{2\pi n_0}{\lambda_0} \), then the diffraction is called Raman-Nath diffraction

(B) If the length of acoustic wave over which the optical beam interacts is large enough, \( L \gg \frac{2\pi n_0}{\lambda_0} \), then the diffraction is known as Bragg diffraction

(C) The Bragg diffraction results in multiple orders symmetrically located on either side of the 0\(^{th}\) order

(D) The Raman-Nath diffraction yields only a single order either +1 or -1 order

No, the answer is incorrect.
Score: 0
Accepted Answers:
(A)  
(B)  
(C)  
(D)  

9) **Which of the following about the acousto-optic diffraction for this configuration is/are true?**
(A) For both Raman-Nath and Bragg diffraction, frequency of the incident wave = frequency of the diffracted wave

(B) In Bragg diffraction, the frequency of diffracted light does not shift

(C) Raman-Nath diffraction is not associated with any Doppler shift in frequency of the diffracted optical beams

(D) The Raman-Nath diffraction happens since the perturbed medium acts as thin phase grating

No, the answer is incorrect.
Score: 0
Accepted Answers:
(A)  
(B)  
(C)  
(D)  

10) **1 point**
In the design of an acousto-optic cell, consider the following parameters: frequency of piezo-electric crystal: 6 MHz, velocity of acoustic wave in water: 1500 m/s, and the wavelength of light to be used for diffraction: λ₀ = 0.6328 μm. Assume RI of water n₀ = 4/3. Then

(A) the value (for determining the required interaction length) of the quantity \( (\lambda^2 n_0) / (2\pi \lambda_0) \) is close to 21 mm

(B) the wavelength of this acoustic wave in water is \( \lambda = 250 \mu m \)

(C) if the width of the cell \( L \leq 1 \text{ cm} \) then the medium forms a volume-index phase grating resulting a Bragg diffraction

(D) for cell-width of \( L = 1 \text{ cm} \), then the angle of +1 order diffracted beam is approximately \( \theta_{+1} = 0.11^\circ \)

No, the answer is incorrect.

Score: 0

Accepted Answers:
(A)
(B)
(D)

11)

If the present configuration and parameters correspond to a Raman-Nath diffraction, then the diffracted beams contain

(A) electric field amplitudes that are proportional to various Bessel functions of order same as the respective order of diffraction

(B) various + m orders of diffracted wave that are frequency downshifted as \( \omega = m\Omega \)

(C) various + m orders of diffracted wave that are directed along \( \sin \theta_m = \frac{m\lambda_0}{n_0 L} \)

(D) a zeroth order diffracted wave that has the same electric field amplitude as the incident wave

No, the answer is incorrect.

Score: 0

Accepted Answers:
(A)
(C)

12)

For the configuration and parameters corresponding to a Raman-Nath diffraction having a cell-width of \( L \), when the value of \( \frac{2\pi}{\lambda_0} \Delta n \cdot L \) is

(A) 2.4048 the 1\textsuperscript{st} order diffraction is absent

(B) 5.520 the 0\textsuperscript{th} order diffraction is absent

(C) 1.85 the 1\textsuperscript{st} order diffraction is maximum

(D) 1.85 the 1\textsuperscript{st} order diffraction corresponds to highest efficiency

No, the answer is incorrect.
Score: 0
Accepted Answers:
(B) (C) (D)