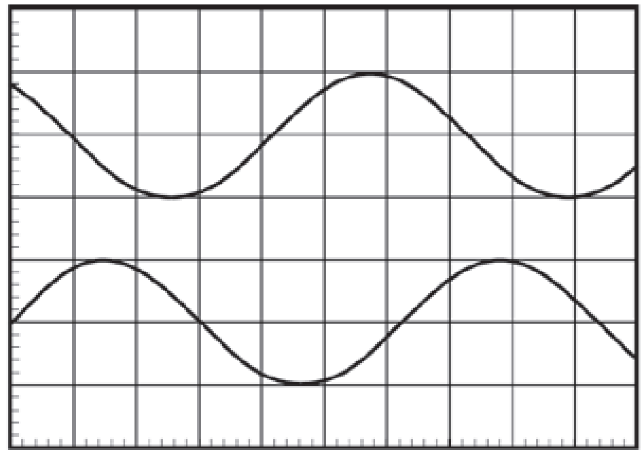
Midterm: Tuesday Nov 1, 2022 **Name:**__________________

Allowed: Formula sheet (given), calculator, 1 hour 50 minutes

PART 1 – answer questions **1-8** in pencil/pen here or in your exam booklet **then** use your scratch card: <u>One</u> scratch = **100%**; <u>two</u> scratches **50%**; <u>three</u> scratches **33%**; <u>four</u> scratches **25%** (part 1 total is 50%)
PART 2 – answer questions **9** & **10** in the exam booklet provided (each of these questions is worth 25%)

Qu's 1–2) Two harmonic oscillations are shown on the right.



1) Which of the following best describes the phase difference that the bottom wave can be considered to be *ahead of* the top wave?

A. 4.12 rads **B.** 1.16 rads **C.** 2.16 rads **D.** 1.51 rads **E.** 0.61 rads

2) Similarly, which of the following best describes the phase difference that the bottom wave can be considered to be *behind* the top wave.

A. 4.12 rads **B.** 1.16 rads **C.** 2.16 rads **D.** 1.51 rads **E.** 0.61 rads

3) The light emitted by a diode laser is centred at 905 nm and has a wavelength spread of 2 nm. Which of the following is the this spread given as a frequency spread?

A. 450 GHz **B.** 220 THz **C.** 220 GHz **D.** 730 GHz **E.** 330 THz

Qu's 4–6) The refractive index for electromagnetic waves travelling through an ionized gas is given by

$$n^2 = 1 - \omega'^2 / \omega^2$$

where ω' is the *plasma frequency* and is determined by the density of the gas.

4) The *dispersion relation* of a wave travelling within a medium relates its *angular frequency*, ω, to the *propagation constant*, *k*, within that medium. Which of the following is the correct dispersion relation for light travelling in a medium with some arbitrary refractive index, $n(\omega)$?

A. $\omega = \dfrac{n(\omega)}{ck}$ **B.** $\omega = \dfrac{ck}{n(\omega)}$ **C.** $\omega = \dfrac{k}{c\,n(\omega)}$ **D.** $\omega = \dfrac{k\,n(\omega)}{c}$ **E.** $\omega = c\,k\,n(\omega)$

5) Which of the following is the formula for the *phase velocity* of monochromatic light with angular frequency, ω_{pk}, travelling through an ionized gas?

A. $\upsilon_{\text{p}} = c$ **B.** $\upsilon_{\text{p}} = \dfrac{c}{1 - \dfrac{\omega'^2}{\omega_{\text{pk}}^2}}$ **C.** $\upsilon_{\text{p}} = \dfrac{c}{\omega'^2 - \omega_{\text{pk}}^2}$ **D.** $\upsilon_{\text{p}} = \dfrac{c}{\sqrt{1 - \dfrac{\omega'^2}{\omega_{\text{pk}}^2}}}$ **E.** $\upsilon_{\text{p}} = c\left(1 - \dfrac{\omega'^2}{\omega_{\text{pk}}^2}\right)$

6) Which of the following is the *product* of the group and phase velocities for a light beam centred at angular frequency ω_{pk} travelling through an ionized gas?

A. c^2 **B.** $c^2\left(1 - \dfrac{\omega'^2}{\omega_{\text{pk}}^2}\right)$ **C.** $c^2\left(1 + \dfrac{\omega'^2}{\omega_{\text{pk}}^2}\right)$ **D.** $\dfrac{c^2}{1 - \dfrac{\omega'^2}{\omega_{\text{pk}}^2}}$ **E.** $\dfrac{c^2}{1 + \dfrac{\omega'^2}{\omega_{\text{pk}}^2}}$

Qu's 7-8) A fringe pattern resulting from two-beam interference (so a graph of intensity against δ) has minimum intensity measured to be 0.45 cm on a graph and maximum intensity measured to be 2.15 cm.

7) What is the *visibility* of this fringe pattern?

A. 0.45 **B.** 0.65 **C.** 0.30 **D.** 1.7 **E.** 3.3

8) Treating one of the interfering beams as having an intensity which is *N* times that of the other, which of the following is a possible value of *N*?

A. 0.09 **B.** 0.84 **C.** 2.2 **D.** 6.2 **E.** 7.2

PART II – answer both questions in exam booklet provided

9. a) The *solar constant* is the intensity from the Sun striking the surface of the earth's atmosphere and is about $0.135\ \text{W/cm}^2$. Treat the incoming light as a harmonic wave with wavelength of 700 nm. Find: (i) the amplitude of the $\vec{\mathbf{E}}$- field of this wave; (ii) the number of photons that arrive each second on each square meter of a solar panel; (iii) the expression for the harmonic wave for the $\vec{\mathbf{E}}$-field of the solar radiation, assumed to be travelling along the z-axis, inserting all numerical constants.

b) A slab of GaAs crystal, used in a diode laser, has a refractive index of $n = 3.6$. What fraction of the intensity of the light generated within the slab and incident normally on one face is reflected from that face?

10. a) Showing your working with the help of a diagram, show that the amplitudes (here, positive numbers) of the first three reflected and first three transmitted beams from a parallel, nonabsorbing glass plate with $n = 1.52$, when the incident beam is near normal and of unit amplitude, are given by

	(1)	(2)	(3)
reflected	0.206	0.198	0.0084
transmitted	0.957	0.041	0.0017

b) Find the visibility of the fringe pattern resulting from the first two *reflected* rays, and also from the first two *transmitted* rays.