UNIVERSITY OF JOHANNESBURG

FACULTY OF SCIENCE

DEPARTMENT OF APPLIED PHYSICS AND ENGINEERING MATHEMATICS

MODULE: PHYSICS PH1BEET

DFC CAMPUS

NOVEMBER

DATE: 05/11/2014

SESSION: 12:30 – 15:30

ASSESSOR: **MR. MJ.MVELASE**

INTERNAL MODERATOR: **DR J CHANGUNDEGA**

DURATION: 3 HOURS **MARKS: 100**

NUMBER OF PAGES: 7 PAGES, INCLUDING 1 INFORMATION SHEET

INSTRUCTIONS: CALCULATORS ARE PERMITTED (ONLY ONE PER STUDENT)

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ANSWER ALL QUESTIONS IN THE ANSWER BOOK PROVIDED

QUESTION 1: [Marks 13]

1.1. Define the term *Refractive index* (3)

1.2. Consider the two travelling waves $\psi_1(x,t) = A\cos\left\{\frac{2\pi}{\lambda}(x - vt)\right\}$ and

$\psi_2(x,t) = A\cos\left\{\frac{2\pi}{\lambda}(x + vt)\right\}$. Their sum is $\psi(x,t) = \psi_1(x,t) + \psi_2(x,t)$.

Show the final form of their superposition (6)

1.3. Show that the following wave equation $\psi(x,t) = A\cos\left\{\frac{2\pi}{\lambda}(x - vt)\right\}$ can

be expressed as $\psi(x,t) = A\cos\{kx - \omega t\}$ (4)

[13]

QUESTION 2: [Marks 21]

2.1. A light ray is refracted at the interface of glass (n = 1.54) and an unknown medium. If the angle of incidence is 55^o and the angle of refraction is 23^o.

2.1.1. State Snell's Law (2)

2.1.2. Draw a sketch of the scenario (3)

2.1.3. Calculate the refractive index of the unknown second medium. (3)

2.1.4. Is the medium denser or less dense than glass? (1)

2.2. A light source at centre of the bottom of a pond of water (n = 1.33) 6.00m deep, emits light rays in all directions. A circle of light is formed at the surface of the water by rays which are refracted into the air. Beyond this circle the rays are reflected back to the water. Calculate the radius R of this circle. (6)

2.3. The region of the deepest section of Pacific Ocean in Marianas Trench, in, is contaminated with unknown fluid after the ship explodes. Here the ocean is as low as 10918 m below the surface. If the refractive index of the water-fluid mixture is 2.79, calculate the time it would take a laser light to reach the bottom of the trench. (6)

[20]

<u>QUESTION 3</u>: <u>[Marks 22]</u>

3.1. A laser light of 8600 $\overset{0}{\mathrm{A}}$ ($\overset{0}{\mathrm{A}} = 10^{-10}\mathrm{m}$) passes through two slits 0.3 mm apart and reaches the screen 2.50 m away

3.1.1. Calculate the fringe width. (4)

3.1.2. Calculate the position of the second dark fringe. (4)

3.1.3. Calculate the position of the third bright fringe. (4)

3.1.4. Calculate the separation of 2^{nd} and 3^{rd} dark fringes on the opposite sides of main fringe. (4)

3.2. Two slits are separated by 0.31 mm. A beam of 400 nm light strikes the slits, producing an interference pattern. How many bright fringes are observed on an angular range $-22.0^{o} < \theta < 22.0^{o}$ (6)

[22]

<u>QUESTION 4</u>: <u>[Marks 14]</u>

L = 2.80 m and *d* = 0.31 mm and assume that the slit system is illuminated with monochromatic of wavelength 900 nm light. The two wave fronts arrive at point *P* on the screen.

4.1. Calculate the phase difference when angle $\theta = 0.73°$ (4)

4.2. Calculate the phase difference when the fringe width $y = 5.00$ mm. (3)

4.3. What is the value of θ for which the phase difference is 0.56 rad? (3)

4.4. What is the value of θ for which the path difference is $\lambda/4$? (4)

[14]

Answer this Section on the UJ Multiple Choice Question grid provided

Section B (Multiple Choice Questions)

1. The acceleration of a particle performing Simple Harmonic motion (SM) is 12 cm.s^{-2} at a distance of 3 cm from the equilibrium. Its time period is:

   A. 2.0 s
   B. 3.14 s
   C. 0.5 s
   D. 1.0 s
   E. None of the above

2. In a Young's double-slit experiment, interference pattern is observed on a screen. The apparatus is then submerged into water. What is the change in the interference pattern?

   A. Interference fringes move close to the central maximum
   B. Interference fringes move away from the central maximum
   C. No change in interference pattern
   D. Bright fringes are replaced with dark fringes
   E. The number of fringes increases

3. An unpolarized light passes through two polaroids; the axis of one is vertical and that of the other is 60^{o} to the vertical. If the intensity of the incident light is I_o, what is the intensity of the transmitted light?

   A. I_o B. $\frac{I_0}{4}$ C. $\frac{I_0}{3}$

   D. $\frac{I_0}{2}$ E. $\frac{I_0}{8}$

4. In the equation $d \sin\theta = m\lambda$ for the lines of a diffraction grating *d* is:

   A. the number of slits
   B. the slit width
   C. the slit separation
   D. the order of the line
   E. the index of refraction

5. The spacing between adjacent slits on a diffraction grating is 3λ. The deviation θ of the first order diffracted beam is given by:

   A. $\sin\left(\frac{\theta}{2}\right) = 1/3$ B. $\sin\left(\frac{\theta}{3}\right) = 2/3$ C. $\sin(\theta) = 1/3$

   D. $\tan\left(\frac{\theta}{2}\right) = 1/3$ E. $\sin(\theta) = 1/3$

6. Which of the following statements about sound wave is / are correct?

   (1) It conducts faster in solid than in gas.
   (2) It can be used to detect the depth of the sea.
   (3) If a hammer strikes a long iron rod, a person at the other side of the rod can hear the sound two times because of the echo.

   A. (1) only
   B. (3) only
   C. (1) and (2) only
   D. (1), (2) and (3)
   E. None of the above

7. Which of the following theories can explain the bending of waves behind obstacles into shadow region?

   A. Particle theory of light
   B. Wave theory of light
   C. Kinetic theory
   D. Special theory of relativity
   E. Classical mechanics

8. Which of the following statements about a sound wave is not correct?

A. It i

B. s produced by the vibrations of particles.

B. It can travel through a medium.

C. It is not a mechanical wave.

D. It can be diffracted.

E Refraction

9. A light beam changes its direction when it strikes a boundary between air and water. Which of the following is responsible for this phenomenon?

A. Diffraction

B. Interference

C. Reflection

D. Refraction

E. Polarization

10. Which of the following statements about sound waves is correct?

A. The velocity of sound waves is not affected by the medium through which it travels.

B. Sound waves travel faster in air than in liquid.

C. Sound waves travel faster in solid than in air.

D. Sound waves cannot travel through a solid.

E. No answer

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Section A+ Section B=70+30=100 Marks

Data Sheet

$$y = A\sin\frac{2\pi}{\lambda}\left(vt - x\right)$$

$$x\left(t\right) = A\cos\left(\omega t + \phi\right)$$

$$n = \frac{c}{v}$$

$$c = f\lambda$$

$$n_1 \sin\theta_1 = n_2 \sin\theta_2$$

$$\theta_c = \sin^{-1}\left(\frac{1}{n}\right)$$

$$I = I_o \cos^2\theta$$

$$d\sin\theta = n\lambda$$

$$d\sin\theta = \left(n + \frac{1}{2}\right)\lambda$$

$$\varphi = \frac{2\pi}{\lambda} d\sin\theta$$

$$\delta = \frac{2\pi}{\lambda} d\sin\theta$$

$$\tan\theta \approx \sin\theta$$

$$\tan\theta = \frac{y}{L}$$

$$\sin\theta = \frac{\lambda}{d}$$

$$\frac{y}{L} \approx \frac{n\lambda}{d}$$

$$\frac{y}{L} \approx \frac{\left(n + \frac{1}{2}\right)\lambda}{d}$$

$$T = \frac{1}{f}$$

Constants

$c = 3\times10^{8}\ m.s^{-1}$ *light speed*
$v = 340\ m.s^{-1}$ *sound speed*