KABARAK UNIVERSITY

SUPPLEMENTARY/SPECIAL EXAMINATIONS

2008/2009 ACADEMIC YEAR

FOR THE DEGREE OF BACHELOR OF EDUCATION SCIENCE

COURSE CODE: **PHYS 210**

COURSE TITLE: **OSCILLATIONS AND WAVES**

STREAM: Y2S1

DAY: **MONDAY**

TIME: **2.00 – 4.00 P.M**

DATE: **17/03/2009**

INSTRUCTIONS

Answer **QUESTION 1** and **ANY OTHER TWO**

PLEASE TURN OVER

QUESTION 1 (40 MARKS)

a) Define the terms i) beat (1 mark)

ii) Resonance (1 mark)

b) An ambulance with a siren of 900Hz sound is moving at 20m/s. What frequency is heard by a stationary observer when the car is;

i) Receding from (2 marks)

ii) Approaching the observer? (3 marks)

(Take velocity of sound to be $340ms^{-1}$)

c) i) What do you understand by the term simple harmonic motion? (1 mark)

ii) Show that the equation of a simple harmonic motion is $m\ddot{x} + sx = 0$ where s is spring constant. (3 marks)

d) Give an expression of a Fourier series. (1 mark)

e) Define the term normal mode. (1 mark)

f) i) Using the equation of displacement as $x(t) = x_m \sin(\omega t - \Phi)$, show that the force law of SHM is given by $F = -kx$ where $k = m\omega^2$ and k is the spring constant. (3 marks)

ii) If amplitude is 4cm at 2 seconds and phase angle is 90^0, determine the displacement of a system when it has angular frequency of 50rads/s. (3 marks)

g) A string vibrating at a frequency of 800Hz has five nodes including the two at the fixed ends. If the string is vibrating at $420ms^{-1}$, find the length of the string. (3 marks)

h) Give two factors that affect wave velocity of a transverse wave. (2 marks)

i) Give the difference between longitudinal waves and transverse waves. (2 marks)

j) Given displacement equation of a SHM as $y = a \sin(\omega t - kx)$, show that linear acceleration $\ddot{x} = -\omega^2 y$. Hence find the displacement for a body moving at $5ms^{-1}$ and angular velocity of 3π rad/s. (4 marks)

k) Show that the solution to a wave equation whose displacement is $y(x,t) = f(ct + x)$ is

$$\frac{\partial^2 y}{\partial x^2} = \frac{1}{c^2}\frac{\partial^2 y}{\partial t^2}$$ (4 marks)

l) A linear density of a string is 1.6×10^{-4} kg/m. A transverse wave on the string is described by the equation $y = (0.021m) \sin[(2.0m^{-1})x + (30s^{-1})t]$. What is;

i) the wave speed (2 marks)

ii) The tension in the string? (2 marks)

m) Give a general solution of displacement of a coupled oscillation of n bodies. (1 mark)

n) Define damping as used in simple harmonic motion (SHM). (1 mark)

QUESTION TWO (15 MARKS)

a) In a forced oscillator the equation of motion is given as

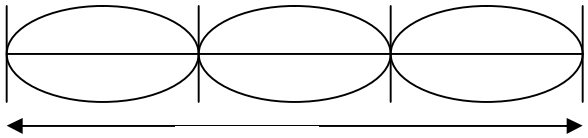
$$m\ddot{x} + r\dot{x} + sx = F_o Cos\omega t$$

Show that

$$x = -\frac{iF_o e^{i(\omega t - \phi)}}{\omega Z_m}$$

Also show that its velocity is $V = \frac{F_o e^{i(\omega t - \phi)}}{Z_m}$ (5 marks)

b) A nylon guitar string has a linear density of 7.2g/m and is under a tension of 150N. The fixed supports are 90cm apart. The string is oscillating in the standing wave pattern shown in fig 1 below:



90cm

Fig 1

Calculate;

i) Speed (2 marks)

ii) Wavelength (2 marks)

iii) Frequency of the traveling waves whose superposition gives this standing wave. (2 marks)

c) A string vibrates according to the equation $y = 0.5\ Sin\ \frac{\pi}{3} x Cos 40\pi t$

Find points on x where there are i) nodes ii) antinodes (4 marks)

QUESTION THREE (15 MARKS)

a) Figure 2 below shows a string in a transverse velocity.

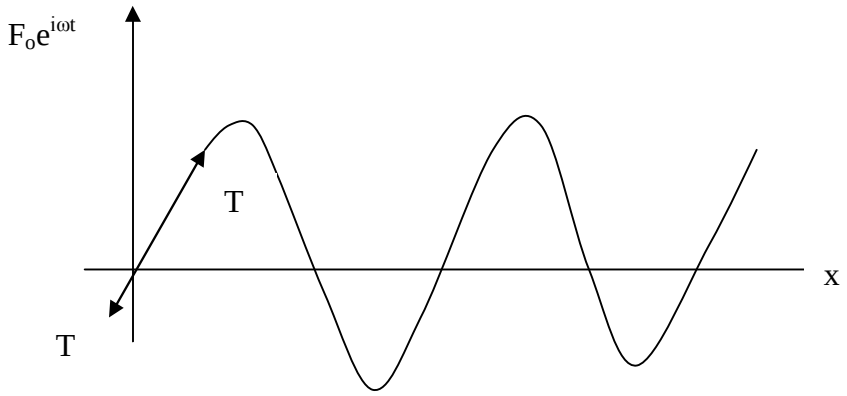


Fig 2

Given that the displacement $y = Ae^{i(\omega t - kx)}$ and that force $F_o e^{i\omega t}$, show that at x = 0 the characteristic impedence of the string Z is given by

$Z = \frac{T}{c}$ where T is the tension and C is the velocity. (5 marks)

b) Calculate the linear density of a string oscillating at $10ms^{-1}$ and has characteristic impedence of $2kgs^{-1}$. (3 marks)

c) In a simple harmonic motion $\ddot{x} + \omega^2 x = 0$, find the solution for $x = a e^{i\omega t} e^{i\phi}$ where **a** is a constant length, and ϕ is also a constant. (3 marks)

d) Define a wave. (1 mark)

e) Given that displacement of a wave is y = A sin ωt, prove that it is also

y = A Sin (ωt – kx)

Where ω is the angular velocity and k is the wave number. (3 marks)

QUESTION FOUR (15 MARKS)

a) The equation below is a matrix form of a coupled oscillation.

$$\begin{bmatrix} \ddot{x}_1 \\ \ddot{x}_2 \end{bmatrix} = -\frac{k}{m}\begin{bmatrix} 3 & -2 \\ -2 & 3 \end{bmatrix}\begin{bmatrix} x_1 \\ x_2 \end{bmatrix}$$

i) Give the original simultaneous equations to this matrix equation. (2 marks)

ii) Solve the equation to obtain the Eigenvalues of the system. (3 marks)

iii) Solve for the corresponding vectors of b) above. (3 marks)

iv) Interpret the meaning of the Eigenvalues. (1 mark)

b) The equation of a transverse wave on a string is

$y = (2.0mm)\ Sin\ [(20m^{-1})x - (600s^{-1})t]$

The tension in the string is 15N.

i) What is the wave speed? (2 marks)

ii) Find the linear density of this string in grams per meter. (2 marks)

c) Find the period of a simple pendulum of length 1.5m carrying a 10g bob. (2 marks)

QUESTION FIVE (15 MARKS)

a) The diagram of fig 3 is an inductor, resistor and a condenser connected in series.

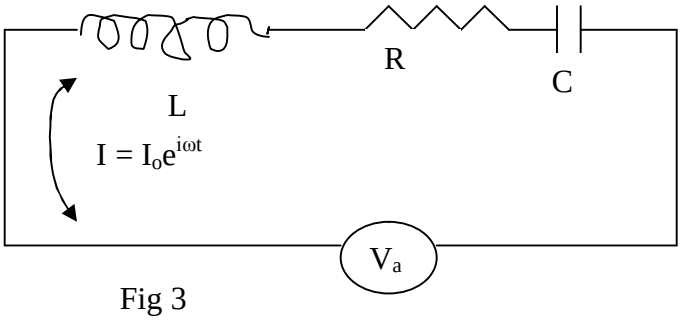


Fig 3

Given that current is $I = I = I_o e^{i\omega t}$,

i) Find the voltage across inductor V_L explaining the relationship between current and voltage (2 marks)

ii) Show that the reactances can be expressed as $i(\omega L - 1/\omega C)$. (3 marks)

iii) Given that $V = V_o e^{i\omega t}$ and $Z = Z_e e^{i\Phi}$, show that

$$I = \frac{V_o}{Z_e} e^{i(\omega t - \Phi)}.$$ (3 marks)

b) At a velocity of $16ms^{-1}$, an impedence of $9kgs^{-1}$ is experienced on a string when a force of 45N is applied on it. Find the phase shift after 3 seconds, if the string is oscillating at 60rad/s. (3 marks)

c) A stretched string has linear density $\mu = 5.0gcm^{-1}$ and a tension of 10N. A sinusoidal wave on this string has amplitude of 0.12mm and frequency of 100Hz and is traveling in the negative direction of x. Write an equation for this wave. Show your working. (4 marks)