SOUTH EASTERN KENYA UNIVERSITY

UNIVERSITY EXAMINATIONS 2016/2017

FIRST SEMESTER EXAMINATION FOR THE DEGREE OF BACHELOR OF SCIENCE (ELECTRONICS)

PHY 201: WAVES AND OSCILLATIONS

9TH DECEMBER, 2016 **TIME: 1.30-3.30 P.M**

INSTRUCTIONS TO THE CANDIDATES

(a) This paper consists of five questions

(b) Answer question **ONE** and **ANY OTHER TWO** questions

Question One 30 marks

a) Given a body executing Simple Harmonic Motion (SHM)

- **i)** State two conditions necessary for SHM to occur **(2 marks)**
- **ii)** For a periodic motion write the condition for periodicity to occur **(2 marks)**

b) A body vibrates periodically exhibiting SHM

- **i)** Write down the basic equation governing SHM **(2 marks)**
- **ii)** Show that $x = Acos\ \omega t$ is solution to the equation in **(b)(i)** above **(2 marks)**

c) Show that the energy of a system in simple harmonic motion is constant **(4 marks)**

d) A system exhibits damped free oscillations

- **i)** What are damped free oscillations? **(1 mark)**
- **ii)** Write the equation of damped free oscillations **(2 marks)**

e) A certain system executes a motion described by the equation below

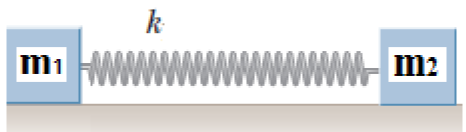
$$m\frac{\partial^2 y}{\partial x^2} + b\frac{dy}{dx} + kx = F_{\circ}e^{jwt}$$

i) Name the kind of oscillatory motion above **(2 marks)**

ii) By putting $Z = Ae^{j(wt+d)}$ derive the expression for the amplitude A **(4 marks)**

iii) Show that the phase angle δ can be obtained as $\delta = tan^{-1}(\frac{\gamma\omega}{\omega_{\circ}^2-\omega^2})$ **(2 marks)**

f) A system of two masses tied together by a spring of constant k as shown may exhibit coupled oscillations



i) State one other example of systems that exhibit coupled oscillations **(1 marks)**

ii) Write the equations of motion for each mass if they are stretched x_1 and x_2 respectively **(2 marks)**

g) For transverse waves propagating through a string;

i) Define the term transverse wave **(1 marks)**

ii) Show that the transverse wave on a string can be described by the equation $T\frac{\Delta\theta}{\Delta x} = \mu\frac{\partial^2 y}{\partial t^2}$

Where T is the tension and μ is the mass per unit length of the string **(3 marks)**

Question Two 20 marks

a) A partially floating body exhibits simple harmonic motion

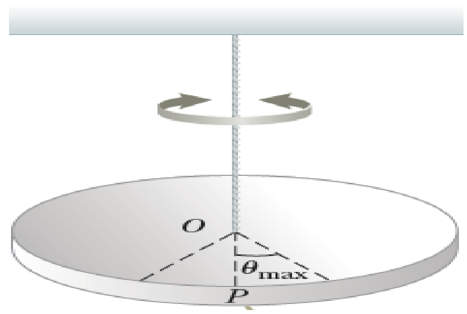
i) Give two example of such bodies **(2 marks)**

ii) Derive the expression for the restoring force **(3 marks)**

iii) Derive the expression for the natural frequency ω **(3 marks)**

iv) Given that body is submerged a depth $l = 0.02m$ determine the period T of the oscillation **(3 marks)**

b) The rotating disc shown below exhibits torsional vibration.



i) Show that the system exhibits SHM **(5 marks)**

ii) Write the expression of its period T in terms of its torsional constant c and the moment of inertia I **(2 marks)**

iii) Find its period T given $r = 0.5m\ mass, m = 0.1kg$ and $c = 0.01kgm^2$ **(2 marks)**

<u>Question Three 20 marks</u>

a) The SHM for a damped free system can be described by the equation $\frac{d^2z}{dt^2} + \gamma \frac{\partial z}{\partial t} + \omega^2 z = 0$

By putting $p = (\alpha + jw)$ in the solution $z = Ae^{(\alpha + j\omega)t}$ of the equation, show the condition; for

i) Critical damping **(3 marks)**

ii) Heavy damping **(5 marks)**

iii) Light damping **(5 marks)**

b) Show that the energy of a damped free oscillator is constant **(7 marks)**

<u>Question Four 20 marks</u>

a) Given that the forces on a vibrating membrane of a drum can be described by

$F_1 = S\Delta y \Delta\theta_z$ for vibration along the YZ plane and $F_2 = S\Delta x \Delta\theta_y$ for the waves along ZX plane

i) Show that these vibration obey the general wave equation $\frac{\partial^2 y}{\partial x^2} = \frac{1}{V^2}\frac{\partial^2 y}{\partial t^2}$ **(6 marks)**

ii) Explain the meaning of following symbols S and $\sigma(sigma)$ you have used in deriving equation in **(4)a)i)** above **(4 marks)**

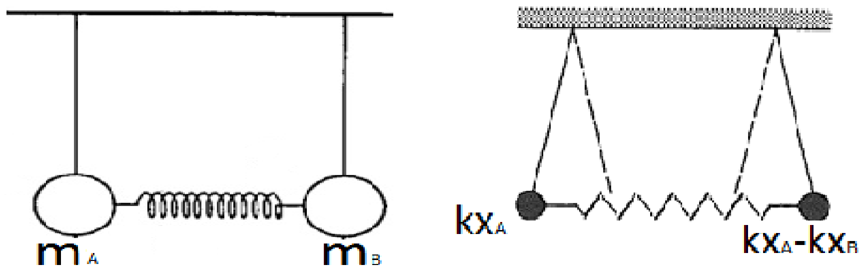
iii) The modes of vibration can be obtained by applying boundary conditions, state the two boundary conditions **(2 marks)**

iv) Write an expression for the lowest frequency $\omega_\circ$ **(5 marks)**

v) The solution for equation in (4)a)i) can be best obtained using Fourier analysis. Explain why **(3 marks)**

<u>Question Five 20 marks</u>

a) A coupled pendulum can be made by tying two massed together using a spring as shown



i) Write down the equation of motion for the mass at point A **(3 marks)**

ii) Write down the equation of motion for the mass at point B **(3 marks)**

iii) By introducing the normal coordinates $q_1 = x_A + x_B$ and $q_2 = x_A - x_B$ show that couple oscillations do not move SHM but show the phenomenon of beats **(6 marks)**

b) Using the equation of force coupled oscillations;

i) derive the expression for the amplitude A **(6 marks)**

ii) Write the expression for q_1 and q_2 **(2 marks)**