TECHNICAL UNIVERSITY OF MOMBASA

Faculty of Engineering and Technology

DEPARTMENT OF ELECTRICAL & ELECTRONIC ENGINEERING

UNIVERSITY EXAMINATIONS FOR THE DEGREE OF BACHELOR OF SCIENCE IN ELECTRICAL & ELECTRONIC ENGINEERING

EEE 2517

ELECTROACOUSTICS

END OF SEMESTER EXAMINATION

SERIES: DECEMBER 2016

TIME: 2 HOURS

DATE:

Instructions to Candidates

You should have the following for this examination

-Answer Booklet, non-programmable calculator, examination pass and student ID

This paper consists of **five** Questions; Question ONE is compulsory. In addition, attempt any Other TWO Questions.

Useful constants and table

Threshold pressure for human hearing, =20µpa

Air density, $\rho = 1.$ *kg/m*^{3}

Reference density, $\rho_0 = 1.18$

Velocity of sound, v=343m/s

Reference sound intensity, $I_0 = 1.0*10^{-12} w/m^2$

$\gamma = 1.4$

$P_0 = 10^5$

OSHA noise HCA 1983 - present	
Exposure time (hrs)	*PEL, dB(A)*
32	*80*
16	*85*
8	*90*
4	*95*
2	*100*
1	*105*
0.5	*110*

Do not write on the question paper.

Question one (30 marks) (Compulsory)

a. Define the following terms as used in acoustics. (4mks)
   i. Decibel
   ii. Sound pressure level

b. Briefly discuss two main merits of logarithmic units. (2mks)

c.
   i. Define a microphone.
   ii. Give two principle purposes of microphones. (3mks)

d.
   i. Give two main disadvantages of horn loudspeakers as compared with direct radiator loudspeakers.
   ii. How can the radiating efficiency of a direct-radiator loudspeaker be increased at low frequencies? (3mks)

e. Determine the sound pressure for a plane progressive one dimensional sound wave with the particle velocity of 0.5cm/s, $\omega = 500$rads/s and a displacement, $\Delta x = 1cm$. (3mks)

f. The y-displacement of a transverse wave travelling in the negative x-direction is y=8.6cos(4.8x+60t), where *t* is measured in seconds, *x* is measured in meters and y is measured in centimeters. Determine the following; (4mks)
   i. Amplitude
   ii. Frequency
   iii. Wavelength and
   iv. Speed of the wave

g. In the deep ocean, a water wave with wavelength 41.2m travels at a speed of 7.5m/s. suppose that a small boat is at the crest of this wave, 0.41m above the equilibrium level. Determine the vertical displacement of the boat above or below the equilibrium level 3.4 seconds later. Note; the boat simply moves up and down. (8mks)

h. A worker in a machine shop is exposed to 95dBA for 2hrs, 69-78dBA for four hours (including a 15min break and 45min lunch), and 90dBA for three additional hours. Calculate the percentage dosage. (3mks)

Table Q1 (h)

Worker's activity	Time	Measured sound level
Milling machine	6.00-8.00am	95dBA
Break room	8.00-8.15am	69dBA
Parts department	8.15-11.15am	78dBA
Lunch	11.15-12.00pm	69dBA
Milling assist	12.00-3.00pm	90dBA

Question two (20 marks)

a. Define an electrodynamic loudspeaker (1mk)

b. Give two advantages of direct radiator type loudspeaker. (2mks)

c. Give two disadvantages of a small diaphragm in a loudspeaker. (2mks)

d. Define the term SWR as used in 'Electroacoustics'. (2mks)

e. The displayed noise, p_r, of a power meter is -80dBm. When a signal p, is applied, the displayed value increases to p_{tot}=-60dBm. Determine the power of the signal p in dBm? (3mks)

f. Given the one-dimensional wave equation as $\frac{\delta^2 p}{\delta x^2} = \frac{1}{c^2}\frac{\delta^2 p}{\delta t^2}$

   i. Give the general solution of this wave equation (2mks)

   ii. Highlight any two observations from (i) above (2mks)

g. Consider the Helmholtz resonator shown in figure 4(g).
A constant force generator G produces a series of tones, among which is one that is not wanted. These tones actuate a microphone M whose acoustic impedance is 250 N.s/m^5. If the tube T has a cross-sectional arc of 10cm^2, L_1=L_2=10cm, L_3=2cm, V=500cm^2, and the cross-sectional area of L_3=4cm^2, what frequency is eliminated from the system? (6mks)

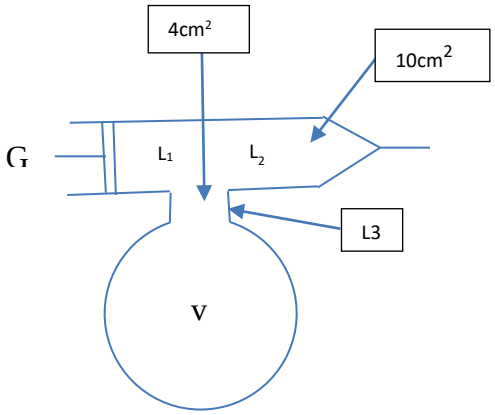

Fig.Q2(g)

Question three (20 marks)

a. Explain the functions of the following parts of the human ear (3mks)

   i. Eardrum

   ii. Cochlea

   iii. Ossicular chain

b. A point source emits 60mW of sound isotropically. A small microphone intercepts the sound in an area of 150mm^2, 400cm from the source. Calculate; (6mks)

   i. The sound intensity at this point

   ii. The power intercepted by the microphone in mW.

c. An eardrum that has an area of 2.5mm^2 receives sound energy at normal incidence at a rate of 6.3*10^{-8} j/s. calculate; (5mks)

   i. The intensity of the sound waves at the eardrum in one second

   ii. The intensity level of sound of this intensity.

d. There are two music systems, A and B, in a room. A person standing in between the two music systems is exposed to sound intensity level of 70dB when system A is on and B switched off. However, when B is on and A switched off, the person is exposed to 68dB sound intensity level. Calculate the intensity

level experience by this person when both A and B are switched on. (6mks)

Question four (20 marks)

a. Differentiate between echo and reverberation. (2mks)
b. Differentiate between absorptive and reactive acoustic filters. (2mks)
c. Given $I_1=1.5*10^{-12}w/m^2$ at a radius of one meter, determine; (5mks)
   i. The sound intensity of a whisper at a distance of 3m
   ii. The corresponding sound intensity level
d. The intensity of EM waves from the sun is $1.5kW/m^2$ just above the earth's atmosphere. 85% of this reaches the surface at noon on a clear sunny day. Suppose you model your back as 35cm by 55cm rectangle. Determine the solar energy incident on your back for two hours. (5mks)
e. It is desired to resonate the cavity in front of the diaphragm of a call loudspeaker, such as that found in a cellphone, to 3kHz using an array of laser drilled sound outlet holes. The cavity has a volume of $0.4cm^3$ and a wall thickness of 1mm. determine the size and number of holes needed, assuming a $Q_A=1.5$ and a ratio of hole diameter to on-center spacing of 0.5. (6mks)

Question five (20 marks)

a.
   i. Explain what you understand by sound power level
   ii. Give two limitations of sound power level. (4mks)
b. Starting from basic principles, show that the difference between two sound intensity levels when $I_2=3I_1$ is 4.77dB. (5mks)
c. Determine the power flow in a freely travelling wave at a fixed point as a function of time, given that pressure, $p(t)=k \sin \omega t$. (3mks)
d. Design a single section T low-pass filter with a cut-off frequency of 100Hz and a Q value of $\frac{1}{\sqrt{2}}$ for critical damping. The filter is driven by a piston at the entrance on the left and terminated with an impedance of $R_0=10^3$ $N.s/m^5$ at the exit on the right. (8mks)