MACHAKOS UNIVERSITY

University Examinations 2018/2019

SCHOOL OF PURE AND APPLIED SCIENCES

DEPARTMENT OF PHYSICAL SCIENCES

FIRST YEAR SECOND SEMESTER EXAMINATION FOR

BACHELOR OF SCIENCE (TELECOMMUNICATION AND INFORMATION TECHNOLOGY)

BACHELOR OF SCIENCE (APPLIED PHYSICS AND TECHNOLOGY)

BACHELOR OF SCENCE (MATHEMATICS)

BACHELOR OF EDUCATION (SCIENCE)

SPH 102: WAVES AND OPTICS

DATE: 10/5/2019 **TIME: 2.00-4.00 PM**

INSTRUCTIONS TO CANDIDATES

I. Answer **questions ONE** and **any other TWO**.

II. Question ONE carries 30 marks while the rest carry 20 marks each.

IMPORTANT CONSTANTS

Young's modulus of steel $= 2.0 \times 10^{11}$ Pa

Density of steel $= 8{,}000\ \text{kg/m}^3$

Density of air $= 1.4\ \text{kg/m}^3$

Ratio of heat capacities, $\gamma = 1.4$

Atmospheric pressure $= 1.0 \times 10^5$ Pa

Speed of sound in air $= 343\ \text{m/s}$

QUESTION ONE (30 MARKS)

a) Distinguish between the following categories of waves and give an example in each.

i. Mechanical waves and Electromagnetic waves (4 marks)

ii. Longitudinal waves and Transverse waves (4 marks)

b) Use sketches to describe each the following properties of light: refraction, diffraction and polarization. (6 marks)

c) A man standing by the road side hears a siren from an approaching Ambulance. Derive the expression for the apparent frequency f' of the sound heard by the man. Given: speed of sound in air is v_a, speed of the ambulance v_s and apparent wavelength of sound is λ' (3 marks)

d) Briefly explain how the Doppler-effect is useful in the medical industry. (3 marks)

e) If a detonator is exploded on a steel railway line, an observer standing on the rail 2.0 km away hears two reports

i. Explain this observation. (2 marks)

ii. Calculate the time interval between these reports. (4 marks)

f) The fundamental frequency of vibration of a particular string is f_0. What would be the fundamental frequency if the length of the string were to be halved and the tension in it were to be increased by a factor of 4? (4 marks)

QUESTION TWO (20 MARKS)

a) What do you understand by the following terms?

i. Resonance (2 marks)

ii. Doppler effect (2 marks)

iii. Red shift of wavelength. (2 marks)

b) Two submarines are underwater and approaching each other head-on. Submarine A has a speed of 12 m/s and submarine B has a speed of 8 m/s. Submarine A sends out a 1550 Hz sonar wave that travels at a speed of 1522 m/s.

i. What is the frequency detected by submarine B? (4 marks)

ii. Part of the sonar wave is reflected from B and returns to A. What frequency does A detect for this reflected wave? (4 marks)

c) A wire of length 400 mm and mass 1.20×10^{-3} kg is under tension due to a weight of 120 N. Determine,

i. The fundamental frequency of vibration, (3 marks)

ii. The frequency of the third harmonic? (3 marks)

QUESTION THREE (20 MARKS)

a) Distinguish between the following types of damping with the aid of a diagram,

i. Over damping (3 marks)

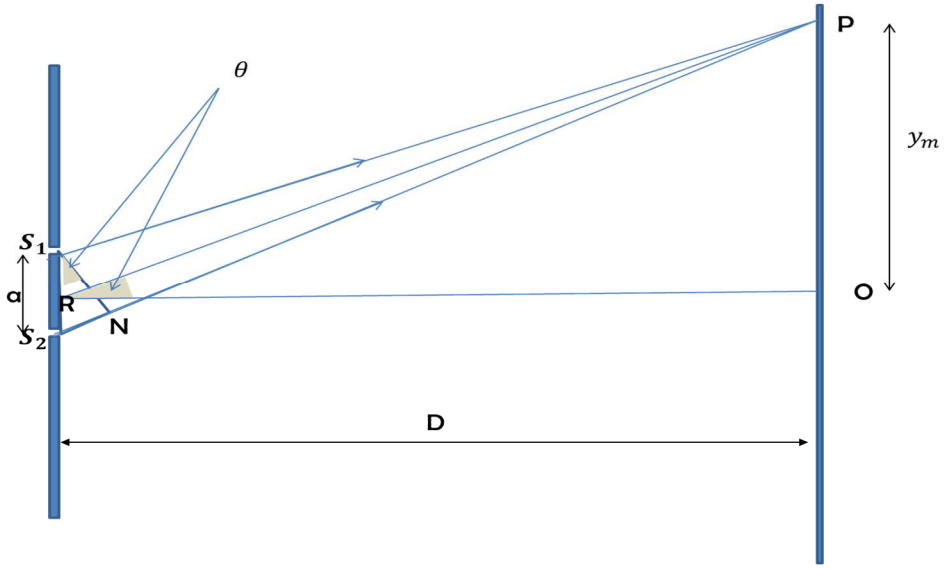
ii. Under damping (3 marks)

b) Identify two examples or situations where critical damping is desired. (3 marks)

c) Sketch the 3rd harmonic of a vibrating string and write down the corresponding equation of its frequency. (3 marks)

d) The Doppler shift may be used in the study of distant galaxies. Explain what is meant by Doppler shift and how it is used to deduce the motion of distant galaxies. (4 marks)

e) In the diagram below, showing the interference of light in a Young's double slit experiment, derive the expression for the m^{th} order distance y_m of bright fringes (maxima) appearing at the point P. (4 marks)



QUESTION FOUR (20 MARKS)

a) Explain why light waves can be polarized while sound waves cannot. (2 marks)

b) State the Brewster's law. (2 marks)

c) Explain with the help of diagrams what is meant by the following terms,

i. Polarization by reflection of waves (3 marks)

ii. Polarization by scattering of waves. (3 marks)

d) State four conditions required for a sustained interference. (4 marks)

e) In a Young's double slit experiment the distance between two slits is 0.2 mm. By interference of light emerging from the slits, 3 mm wide fringes are produced on a screen placed 1 m away from the slits. Calculate,

i. the wavelength of light incident on the slits (3 marks)

ii. the distance of the dark fringe from the central fringe (3 marks)

QUESTION FIVE (20 MARKS)

a) Briefly describe what you understand by the following terms.

i. Blue shift effect (2 marks)

ii. Bulk modulus (2 marks)

iii. Resonance (2 marks)

b) The spectral lines for a given element in light received from a distant star are shifted towards the longer wavelength by 0.032 %. Find the velocity of the star in the line of sight. (3 marks)

c) Find the speed of sound in water which has a bulk modulus of $2.1 \times 10^9\ \mathrm{N/m^2}$ and a density of $1.0 \times 10^3\ \mathrm{kg/m^3}$. (3 marks)

d) A stretched string is observed to vibrate with a frequency of 40 cycles per second in its fundamental mode when the supports are 0.6 m apart. If the string has a mass of 3.0×10^{-2} kg. Calculate,

i. the velocity of propagation of the transverse wave in the string. (3 marks)

ii. the tension in the string. (3 marks)

iii. the frequency of second overtone. (2 marks)