SIR ARTHUR LEWIS COMMUNITY COLLEGE

DEPARTMENT OF TECHNICAL EDUCATION AND MANAGEMENT STUDIES

FINAL EXAMINATION MAY2014

PROGRAMME TITLE(S)	:	Computer System Engineering; Electronic Engineering Automotive Engineering; Mechanical Technicians
PROGRAMME CODE(S)	:	CSE; ESE; AUT; MEC
COURSE TITLE	:	Applied Engineering Science 1
COURSE CODE	:	ESC 103
DURATION	:	3 HOURS
TIME	:	9:00 am
DATE	:	Friday 16th May 2014
ROOM	:	TRB-LAB
COURSE TUTOR	:	Mr. N. Heeralall & Mr F. Combie
INVIGILATORS	:	**V. Etienne**; P. Larode

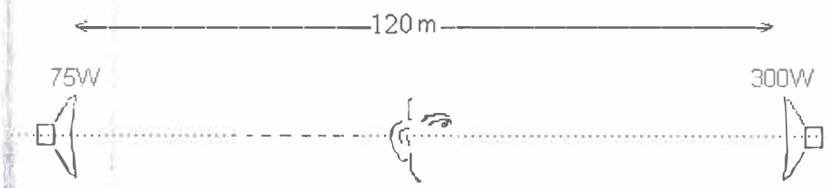
INSTRUCTIONS

1. Answer **eight (8)** questions, **four (4)** from each SECTION
2. Ensure your answers and pages are numbered correctly
3. Ensure neat and clear explanations and presentation.
4. Ray diagrams need not be to scale, but MUST be neat and clearly show all relevant information.
5. Formulae Sheet is presented to the end of the examination.

SECTION A

Question 1

Two amplifiers rated at 75 Watts and 300 Watts per channel respectively, are connected to identical speakers placed 120 meters apart, as shown below. An observer is standing halfway between the speakers.



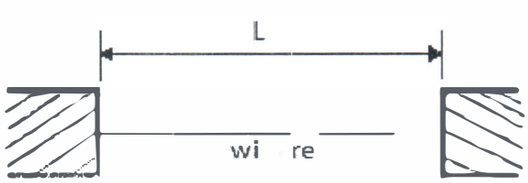
a) Calculate the decibel level the listener would experience if:
   i. only the 300W speaker was operating? [2]
   ii. only the 75W speaker was operating? [2]
   iii. with BOTH speakers operating? [3]

b) If the observer is to move such that the decibel experience from both speakers is the same, calculate the distance from the 75 W speaker. [5]

[12 marks]

Question 2

a) In the physics laboratory at SAI.CC, students carried out experiments on a wire clamped taut between two horizontal supports. The objectives were to observe the standing waves and to measure their frequencies, as the force applied in plucking the wire, was varied. In the data collected, included three consecutive frequencies, 624Hz, 780Hz and 936Hz.



   i. determine the harmonics of these three frequencies. [2]
   ii. calculate the fundamental frequency of the system. [1]
   iii. determine the relationship between the fundamental frequency f_0 and the distance L. [2]
   iv. produce the standing wave outline for the 624Hz harmonic. [2]

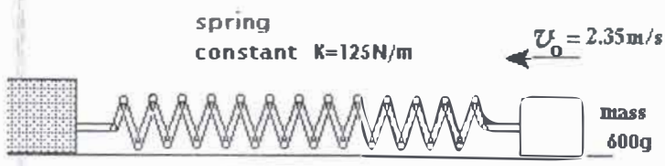
b) Given that the wire had a total length of 4500 mm and a mass of 75.0 g and is clamped between two supports 3400 mm apart to a tension of 4000N. Calculate the velocity of the wave traveling along the wire. [1]

c) A change in the atmospheric temperature, caused the tension of the wire to be decreased by 8%. What will be the corresponding percentage change in the fundamental frequency? [4]

[12 marks]

Question 3

a) What is a Simple Harmonic Oscillator? [2]



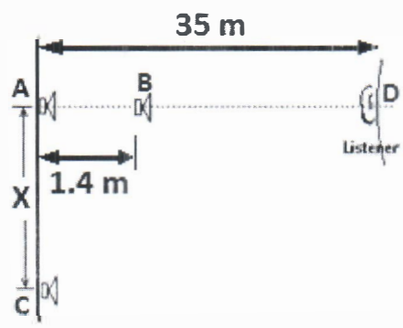
b) A 600g mass at rest on the end of a horizontal spring (K= 125N/m) is struck by a hammer, which gives it an initial speed of 2.35 m/s. Determine:

i. the period and frequency of the motion. [3]
ii. the maximum velocity [1]
iii. the maximum acceleration. [2]
iv. the amplitude. [1]
v. the total energy. [1]
vi. the velocity at a distance of 2.4 cm from its equilibrium position. [2]

[12 marks]

Question 4

a) Two identical speakers emitting identical waves, are located 1.4 meters apart in a straight line from a listener 35 meters, as shown in the diagram. When the wavelength is gradually increased, the listener finds that at certain wavelengths the sound seems to appear very loud.



i. Clearly explain why the sound seems to increase in volume at certain wavelengths and not at others. [4]
ii. What is the largest wavelength at which the loudest sound, is observed? [1]
iii. Give one other frequency at which the same effect is observed? [2]

b) If the speaker **B** is moved to a point along the wall to **C**, emitting the same wavelength as in 4 a) ii. Calculate the distance **X**, at which the first "**no sound**" point from the center of **X**, with the observer still at **D**. [5]

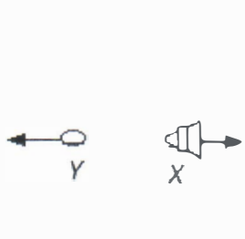
Assume the velocity of sound in air v = 343m/s

[12marks]

Question 5

a) Making reference to the relevant diagrams, explain why an observer would hear a different sound level as the sound source approaches the observer. [4]

b) The diagram represents a car X of $30 ms^{-1}$ travelling away from car Y of $40 ms^{-1}$, which is travelling away from a wall R. Car X is playing music at a frequency of 1500 Hz. The driver in car Y hears the music directly from car X. Find the frequency at which the music is reaching the driver in car Y.



[3]

c) The frequency of a steam train whistle as it approaches you is 522 Hz. After it passes you, its frequency is measured as 486 Hz. How fast was the train moving(assume constant velocity)? [5]

Assume the velocity of sound in air v = 343m/s

[12 marks]

Question 6

a) Explain the terms:
   i. wave front [1]
   ii. beat frequency [1]
   iii. transverse wave [1]
   iv. stationary wave [1]
   v. human audio range [1]

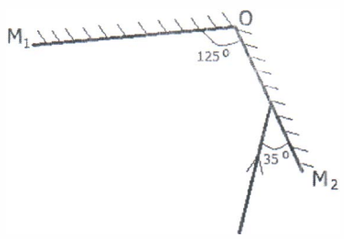
b) Explain three(3) characteristics of sound. [3]
c) Calculate the first two harmonics for a closed pipe 3.5 meters long. [3]
d) Calculate the speed of sound at 28°C. [2]

[12 marks]

SECTION B

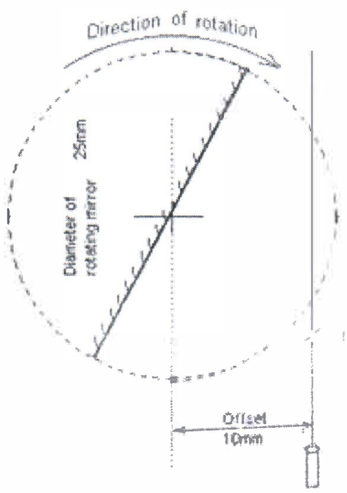
Question 7

a) The figure shows two mirrors inclined to each other at an angle of 125°. A ray of light is incident on mirror M_2O at an angle of 35°. Calculate the angle at which the ray leaves the second mirror M_1O



[3]

b) The diagram shows a scanner in which a laser beam is directed on to a rotating plain mirror. The mirror has a diameter of 25mm and the laser beam is offset from centre by 10mm. As the mirror rotates it intersects the beam which is reflected towards the target area.



   i. Draw a ray diagram showing how the reflected beam will sweep an arc across the target area. [2]
   ii. Calculate the angle of the arc through which the beam scans. [4]
   iii. What should be the offset if the target area is to be limited to 70° [2]
   iv. If the mirror rotates at a speed of 100RPM, what angular speed (in radians per second) does the beam sweep across the target area. [1]

[12 marks]

Question 8

a) Show using suitable diagrams why a spherical mirror offers an advantage for use as a rear view mirror on vehicles. [3]

b) A dentist wants a small mirror that, when 24mm from a tooth, will produce a upright image, three and a half times(3.5x) the height of the object. Draw a ray diagram showing how the image is produced. [3]

   i. What type of mirror should be used? [1]
   ii. What is the focal length of the mirror? [4]
   iii. Where is the image located? [1]

[12 marks]

Question 9

The diagram shows a ray light entering the surface of oil at an unknown angle of incidence θ°. The light passes through the oil, strikes and enters the glass and is **just totally internally reflected** at the glass/air boundary.

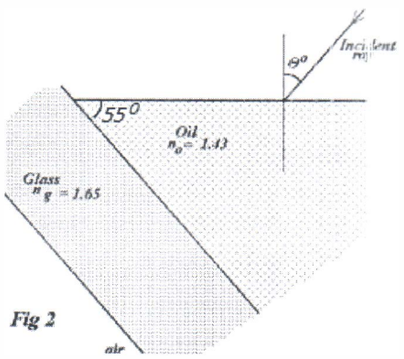


Fig 2

a) Calculate the critical angle at the glass air boundary. [2]

b) Determine the path the light takes as it passes through the different media, stating clearly the incident angle θ. [5]

c) If the area below the glass was occupied by water, determine the path the light would take with an incident angle of 45° [5]

Refractive index of Oil $n_{oil} = 1.43$

Refractive index of Glass $n_{glass} = 1.65$

Refractive index of water $n_{water} = 1.55$

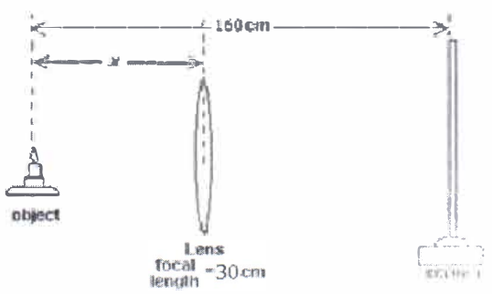
[12 marks]

Question 10

a) Draw a ray diagram showing how a spherical lens produces an inverted magnified image. [4]

b) If the lens, in part (10a) above, is immersed below the surface of water, and used to view an object in the water, what effect will this have on the final image? [2]

c) A luminous object is placed 160 cm away from a screen as shown in the diagram to the right. A converging lens of focal length 30 cm is placed between the object and the screen and moved left and right until a sharp image is formed on the screen. What distance(s) from the object should the lens be located to produce the sharp image and the magnification (in each case)?



[6]

[12 marks]

Question 11

a) The Young's double slit experiment employed a ***monochromatic*** light source, a barrier with ***an initial slit*** followed by a second barrier with ***two slits***, then the screen. In the statement above, explain the significance of the items highlighted and why were they important to the experiment. [3]

b) Two radar transmission towers located 6.4 km apart emit identical signals in phase with each other. A ship located at a point 30 km equidistant from the towers experiences a strong signal from the towers. However, as it sails parallel to the line of the towers it experiences an alternating diminishing and re-strengthen of the signal strength. If the distance between central (strong) signal and the next strong signal is 3.2km then:

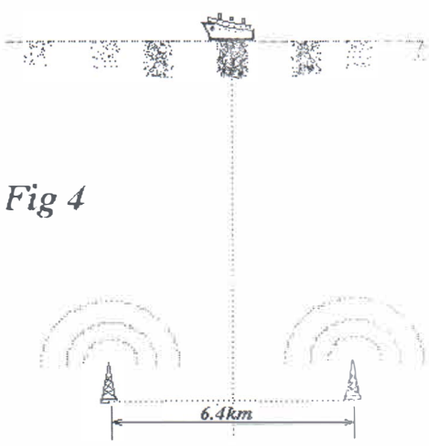


Fig 4

i. Calculate the wavelength and frequency of the signal emitted by the towers. [3]

ii. What would be the limitations of using such a signal for a mountainous terrestrial application? [1]

c) What would be the effect on the distance between strong signals if:

i. The distance between the towers was decreased [1]
ii. The ship was a greater distance away from the towers [1]
iii. The signals had a longer wavelength [1]

[12 marks]

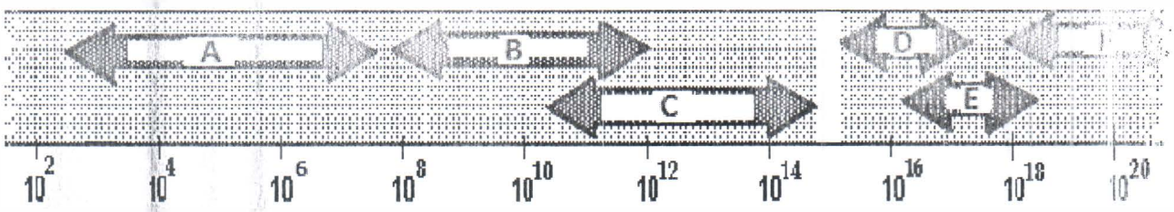
Question 12

a) A very short burst of light (a pulse of light) of wavelength 1062 nm, that lasts for 30 picoseconds was used to send a signal to a receiver on a satellite orbiting 25,000 km above the emitter.

i. How long does it take for the signal to arrive at the satellite? [2]
ii. How many wavelengths are contained in the duration of the pulse? [3]
iii. How short should the pulse be for it to fit two wavelengths? [1]

b) State briefly Maxwell's equations (in worded form). [3]

Electromagnetic Spectrum



Frequency (Hz)

c) Identify the frequency bands indicated in the Electromagnetic spectrum above and state one application of each. [5]

d) Explain why it is usually possible for us to see through the glass door into the domestic microwave oven yet the microwave radiation cannot escape through the door and cause harm. [1]

[12 marks]

FORMULAE SHEET

Refraction, Reflection & Snell's Law

$$\frac{1}{f} = \frac{1}{u} + \frac{1}{v}$$

$$M = \frac{h_i}{h_o} = \frac{v}{u}$$

$$n = \frac{real\ depth}{apparent\ depth}$$

Young's double slit experiment (waves)

$$n\lambda = \frac{xd}{l}$$

$$d\ Sin\theta = m\lambda$$

$$d\ Sin\theta = (m + \tfrac{1}{2})\lambda$$

Simple harmonics Oscillators

$$F = -k\,x$$

$$KE = \tfrac{1}{2} m v_o^{\,2}$$

$$PE = \tfrac{1}{2} k A^2$$

$$v = \pm\, v_o \sqrt{1 - \frac{x^2}{A^2}}$$

$$v = \pm\, \omega \sqrt{A^2 - x^2}$$

$$v = \sqrt{\frac{T}{m/l}}$$

$$f = \frac{1}{2\pi}\sqrt{\frac{k}{m}}$$

$$T = 2\pi\sqrt{\frac{l}{g}}$$

$$x = Sin\omega t$$

Sound, Intensity & The Doppler Effect

$$v = \sqrt{\frac{B}{\rho}}$$

$$Intensity = \frac{power}{area}$$

$$I \propto \frac{1}{r^2}$$

$$\beta = 10\log\frac{I_1}{I_2}$$

$$f' = \frac{f}{\left(1 \pm \frac{v_s}{v}\right)}$$

$$f' = f\left(1 \pm \frac{v_o}{v}\right)$$

$$c = 3\times10^8\ m/s$$

$$v \approx (331 + 0.6T)m/s$$

END OF EXAMINATION